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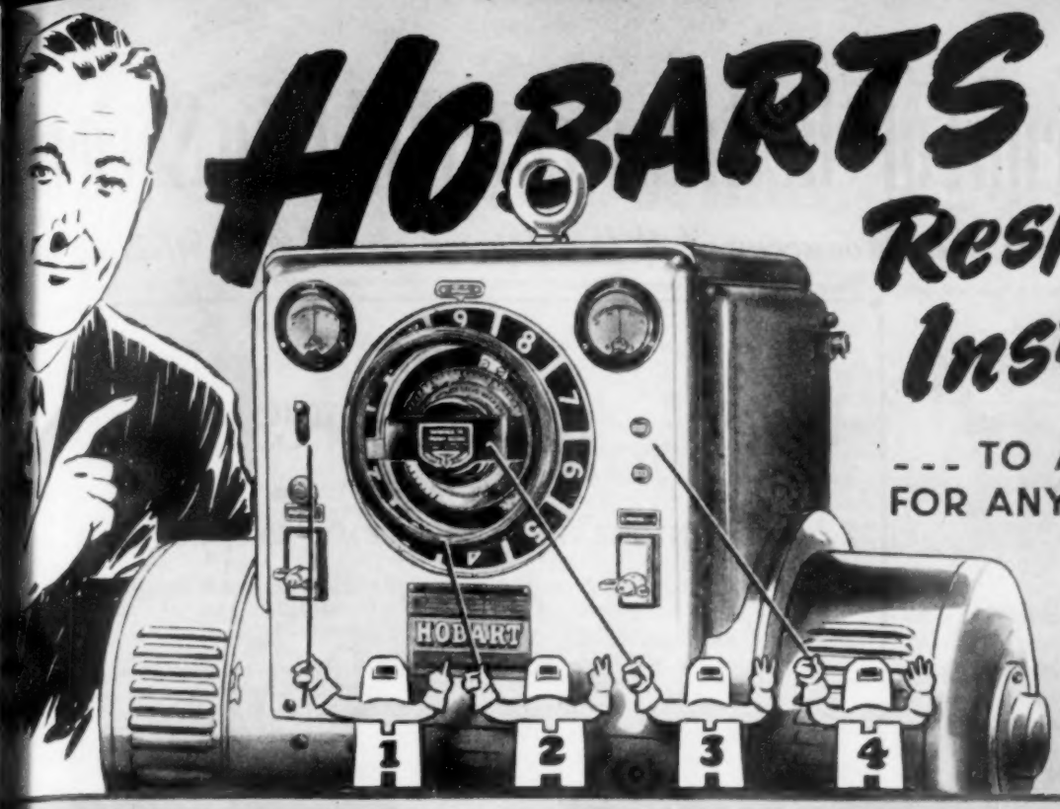

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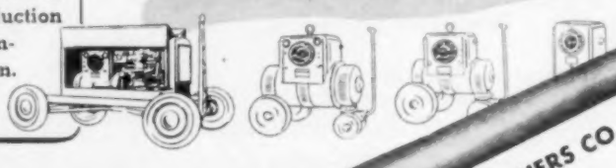

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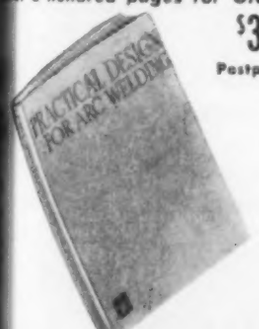

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Published for the Advancement of the Science and Art of Welding

W. SPRARAGEN, Editor

MARCH, 1945

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Flame-Cutting Side Frames from Steel Plate at By-Products Steel Corporation, Coatesville, Pa., for Hundreds of Railway Locomotives for Europe.

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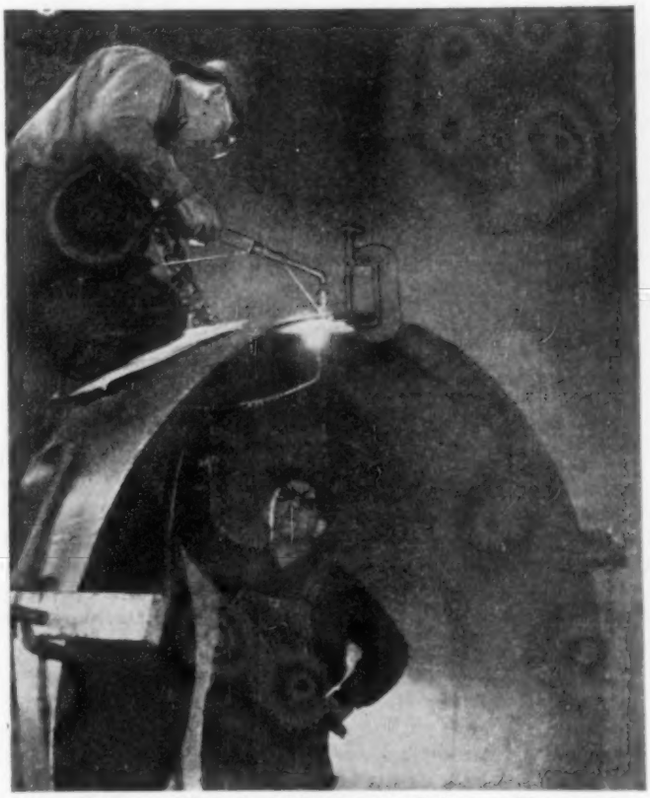
Fusion Welding, Copper, Brass and Bronze*

By H. R. Morrison†

THE number of alloys of copper manufactured today is well over a hundred. Most of these alloys are weldable. A few, however, are not welded because of their metallurgical properties, or because welding is unnecessary in the special applications for which they are used. The weldable alloys of copper fall into four general groups:

1. Copper itself and those other materials that contain a small enough percentage of alloying elements or impurities to be considered in the same class with copper.
2. Copper-zinc alloys, or brasses, that are formed by adding zinc alone or zinc and some other element to copper.
3. Copper-tin alloys, or bronzes.
4. Copper-silicon alloys, including Everdur metal.

Each group consists of alloys of copper that have welding techniques, properties and characteristics that are alike or very similar.



One Common Method of Maintaining Sufficient Heat in the Weld Zone Is to Use Two Welding Blowpipes. Here, a Second Blowpipe Is Being Used as a Supplementary Source of Heat

I. Copper

Copper is one of the purest metals used commercially. The ordinary copper that is used for tubes, wires, sheets and plate is 99.9% pure. It has excellent workability either hot or cold and the highest electrical and heat conductivity of all commercial metals. Its corrosion resistance is excellent.

In general, commercially pure copper is divided into two principal types, electrolytic tough-pitch copper and deoxidized copper. Electrolytic copper contains from 0.01 to 0.08% oxygen, usually in the form of oxides. When the base metal is heated to a temperature near the melting point of copper, these oxides cause a metallurgical change which results in as much as 6% reduction in the tensile strength of the metal. Because the metal in the neighborhood of the weld zone reaches the temperature at which this change occurs, this weakening effect always occurs in electrolytic copper in the area adjacent to the fusion weld zone. Therefore, if strengths comparable to the original base metal are required, it is better to use a type of copper that is not subject to this weakening condition.

The Utility of Welding in the Installation of a Copper Piping System in a Paper Mill Is Shown Here. The Pipe Was Made from Sheet Copper by Forming and Welding the Longitudinal Seam

* This article is a digest of a portion of the new *Oxy-Acetylene Handbook*. For the detailed discussion of this subject see *The Oxy-Acetylene Handbook*, pp. 317 to 329.

† The Linde Air Products Co.

Deoxidized Copper

Copper-base metals have been developed that are completely free from oxygen. These come under the general term "deoxidized copper" and are commercially available as rods, tubes, sheets and plates.

Deoxidized copper has certain welding properties that must be understood by the operator before attempting to weld the metal for the first time. Copper does not have any plastic range. It is solid until it actually reaches the melting point of 1980° F., whereupon it transforms immediately to a liquid state. Because of its high coefficient of expansion, copper will expand more during heating and contract more during cooling than will other metals. This results in greater stresses set up during welding and greater possible distortion than in steel welding.

To the operator making his first weld on copper after having worked on steel the most noticeable difference will be the greater heat conductivity of copper. This causes the heat to flow rapidly into the base metal with a consequent chilling effect upon the weld. Three common methods are used to overcome this chilling effect:

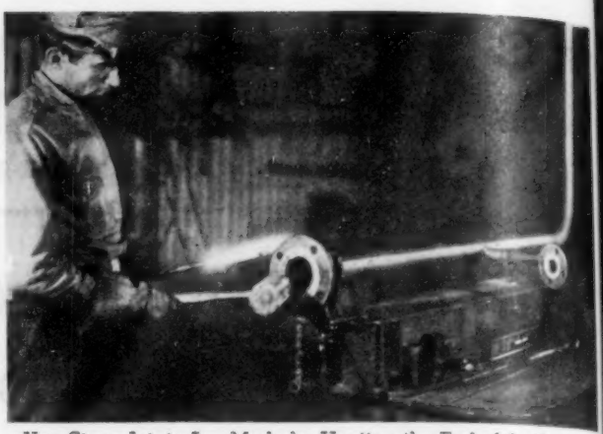
1. The base metal can be covered with an insulating material such as asbestos.
2. The base metal can be preheated completely in a furnace with a torch burning city gas or other low-cost fuel.
3. Two operators can weld simultaneously:
   (*a*) One may make a thin deposit at the bottom of the vee while the other completes the weld—the two welding puddles being but a few inches apart so that one blowpipe can take advantage of the heat supplied by the other blowpipe.
   (*b*) The weld may be made from two sides of the material simultaneously.
   (*c*) The second blowpipe may be used as a supplementary source of heat.

The third method is most generally used in copper welding. Insulating the base metal reduces the dissipation of heat to the air, but the conduction of heat through the metal is far too rapid to make this method of great help. The general preheating of the part is used principally for repetitive or production work, particularly on small parts. Preheating should be carried only to a black heat.

Joint Design

The joint design for welding copper is essentially the same as that for welding steel.

It is sometimes desirable to back up the weld, because of the fluidity of the molten copper. This may be done by using a flat sheet of steel covered with a sheet of asbestos. The asbestos should be grooved under the joint in the copper to allow for complete penetration.



Van Stone Joints Are Made by Heating the End of the Pipe and Hammering It Out Flat Onto the Flange. They Are Useful in the Installation of Nonferrous Piping Systems

Tip Size and Flame Adjustment

Because of the high heat conductivity of copper, more heat is required for welding this metal. Therefore, it is desirable to select a tip one or two sizes larger than is normally used for steel of the same thickness. A neutral flame adjustment is used for welding copper. The accompanying table gives some information regarding the variable factors in copper welding.

A completely deoxidized welding rod, preferably with a slightly lower melting point than the base metal, should be used. Such a rod has the advantage of allowing the initial contraction of the base metal in the weld zone to take place before the welding rod metal solidifies.

In general, flux is not needed in making fusion welds in copper. However, occasionally the sparing use of Brazo flux assists in the welding action.

It is common practice to tack-weld the parts before welding. During welding the tack welds should be melted out and rewelded. The function of tack welds in long seams is to prevent the gap from closing up. Often the number of tack welds can be reduced to just a few by placing wedges or clips in between them. This saves time spent on melting out numerous tack welds. The wedges or clips are removed a few inches ahead of the welding action.

If copper material is not tack-welded, a greater spread must be allowed at the finishing end of long seams than would be allowed in similar length seams in steel.

In general, standard jigging principles apply to copper welding, but there is no need to use chill plates because

Data on Oxyacetylene Welding Copper

Thickness of Base Metal, In.	Welding Tip Size, Drill Size	Heating Tip Size, Drill Size	Number of Operators	Joint Design	Spacing, In. (Tack-welded 5 In. C to C)
1/16	55–58	...	1 welding	Flange	None
1/16	55–58	...	1 welding	Square butt	1/16–3/32
1/8	51–54	...	1 welding	Square butt	3/32–1/8
3/16	48–50	43–46	1 welding 1 heating	Single-vee 60–90°	1/8–3/16
1/4	43–46	43–46	1 welding 1 heating	Single-vee 60–90°	1/8–3/16
3/8	38–41	38–41	1 welding 1 heating	Single-vee 60–90°	3/16
1/2	38–41	38–41	2 welding	Double-vee 90°	3/16
3/4	38–41	38–41	2 welding	Double-vee 90°	3/16

of the high heat conductivity of copper. Since copper is rather weak at temperatures near the melting point, jigs should not be fastened too tightly during the cooling through this range of temperatures.

Welding Technique

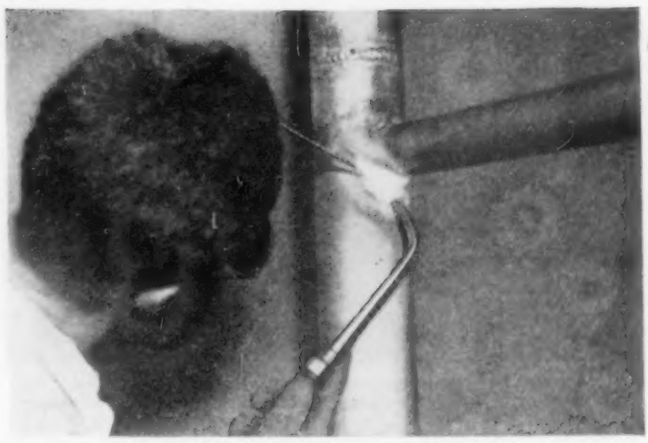
The actual welding technique for making a fusion weld in copper is very much the same as in steel base metal with the exception of the factors already pointed out. Copper weld metal is more fluid than steel, but complete puddle control can be obtained by proper manipulation of the welding rod and of the welding flame. The base metal should be melted before the welding-rod metal is allowed to flow on it. If the rod metal is allowed to flow upon red-hot but solid base metal, there will be a bond of some strength, but not of the maximum strength that results from an actual intermingling of the base metal and welding-rod metal.

Whenever possible, and if the base-metal thickness is not too great, a weld in copper should be completed in one pass. If it is necessary to make more than one pass, the second pass should never start at an edge, but should be started 4 or 5 in. in from an edge. Then, after it has been completed in one direction, it should be restarted at the original point and completed in the other direction. The same procedure should be used if the weld is annealed with the blowpipe. The reheating should be started at least 4 in. in from the edge, heated first in one direction, and then from the starting point out to the other edge.

Aftertreatment

Following the fusion welding of oxygen-free copper, it is good practice to peen or hammer the weld to reduce the grain size and to reduce any locked-up stresses. This may be done on the cold metal, while the metal is hot from the welding operation, or when the weld has been reheated for hot-working. Usually it is preferable first to peen a weld and then to hammer it to remove the marks of the peening operation—working a small area at a time so as not to cause undue bending. Cold-peening or cold-hammering will raise the tensile strength, with an accompanying reduction in ductility.

The General Principles of Jigging Apply to Copper Welding. It Is Sometimes Desirable to Back Up the Weld, as Shown Here, Because of the Fluidity of the Molten Copper



The Oxyacetylene Flame Is Used in the Installation of Piping Systems of Commercial Yellow Brass Pipe Both for Forming the Openings and for Welding the Joints

If such an operation is followed by heating the weld to a red heat, the ductility will be restored, while the strength and hardness, although lowered, will be improved over the untreated welds. The hammering or peening operation should extend through the entire weld zone and the adjacent area. Material thicker than 0.22 (14-gage) should preferably be peened hot, while material thinner than this may be cold-worked. The area being hammered should be supported from the reverse side. If fusion welds are made in electrolytic copper, hammering and annealing must always follow the welding operation to obtain adequate strength.

Bronze-Welding Copper

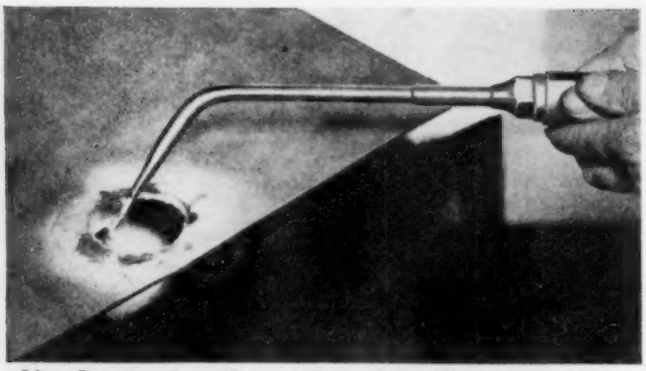
The regular bronze-welding rod and technique are used in bronze-welding copper. The lower temperature of bronze welding minimizes the problem of chilling and frequently increases the speed of welding. A slightly excess-oxygen flame adjustment and Brazo flux is applied to the rod from time to time by dipping the heated rod in the can of flux.

Bronze welding cannot be used when it is necessary to have an exact color match between the weld metal and the copper base metal; neither can it be used in certain chemical applications, since the bronze-weld metal is not so resistant to corrosive attack as the copper base metal. Although bronze welding can be used for joining electrolytic copper, it is more frequently used on deoxidized copper. The bronze-welds should be made as rapidly as possible, especially in electrolytic copper.

II. Copper-Zinc Alloys—Brasses

When zinc alone or zinc and some other element are added to copper, these alloys are usually called brasses. The most important factor in the welding of brass is that zinc has a relatively low boiling point and therefore vaporizes easily. This vaporization of zinc may be restricted by the addition of certain elements to the base metal and by using a suitable flame adjustment during welding. In general purpose bronze welding rods, elements have been added to reduce the vaporization of the zinc during welding.

The same joint design is used for welding brass as for welding steel of the same thickness. For brass pipe and tubing, the straight butt weld is recommended for wall thicknesses greater than $^1/_8$ in. In light-wall brass tubing the bell-and-spigot type joint is sometimes used. A



After Painting Iron Cement Around the Opening and Preheating the Metal to Be Removed to a Red Heat, the Oxidizing Flame Is Used to Melt Out the Opening

welding rod of composition similar to the base metal is recommended for welding brass.

Flame Adjustment for Brass

When brass base metal is brought almost to the melting point by means of a neutral flame, zinc fumes start coming off and the surface of the metal is rather bright. If the flow of acetylene is then gradually reduced, or the flow of oxygen increased, it will be noticed that at a certain point of excess-oxygen flame adjustment a distinct coating is formed on the surface of the brass. The flame adjustment at this point is strongly oxidizing, but the excess of oxygen in the flame should not be increased further, as the coating or film will then become so thick and refractory as to interfere with the welding action. By using the oxidizing flame adjustment which just begins to produce film, i.e., when the coating just becomes visible, the boiling and fuming of the base metal will be practically eliminated. This is the point at which the best welds, free from porosity and with good tensile strength, are produced.

It is necessary to use a suitable flux whether any rod metal is being added or not, due to the formation of the coating on the molten puddle. Both Brazo flux and Cromaloy flux have been found satisfactory for welding these metals. The flux should be applied by mixing it with water to form a paste, which is painted both on the rod and on the base metal.

Welding Technique for Brass

The technique for depositing rod metal in welding brass is similar to that used for welding steel. Either forehand or backhand welding may be used, but forehand welding generally will produce more satisfactory results.

The tendency of zinc to volatilize from the molten puddle is increased if the puddle is overheated. Efforts should therefore be made to use just a sufficient amount of heat to make the weld properly. Certain brasses can be joined with general purpose bronze welding rod, but they are of different composition and have a melting point slightly higher than that of the rod. These brasses can be joined by a bronze-welding technique even though the difference in melting point between that of the welding rod and that of the base metal is not great enough to make it a true bronze-weld. However, with an alloy such as 95% copper and 5% zinc, best results are obtained by welding with a general purpose bronze welding rod and a true bronze-welding technique, rather than by making a fusion weld.

Flame-Shaping Brass

In many operations on brass, particularly in brass piping installations, openings of various sizes are required. It is frequently easier and cheaper to melt out the opening with the oxyacetylene flame than to use mechanical means to cut it out. Even the ends of brass pipe for branch connections can be shaped in this way.

The opening, regardless of shape, is first laid out on the work. A mixture of water and a quick-drying iron cement, such as is used in calking bell-and-spigot joints, is then applied by brush around the outer limits of the scribed opening. This paste mixture should be thick enough to build up on the brush considerably without dripping. One or more coats may be required to paint a band $1/2$ to $3/4$ in. wide completely around the desired opening. As the paste dries under the heat of the blowpipe flame, it acts as a refractory material and protects the metal underneath. This limits the melting of the metal to a certain extent and aids in keeping the melting in the area it is desired to remove.

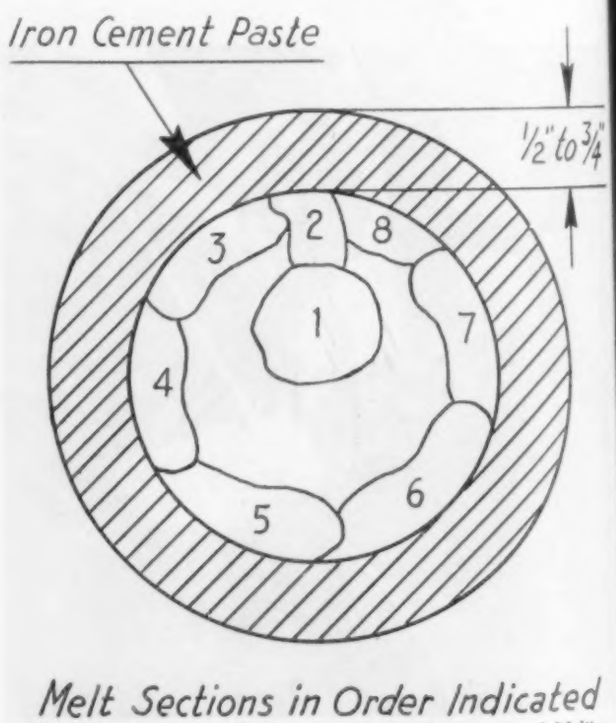
The excess-oxygen flame is used to melt out the desired shape. The flame is tilted so that it points in the direction of melting at an angle of about 30° to the surface of the metal. As the outer limits of the opening are approached, the blowpipe is gradually straightened up to square off the melted edge. Any solidified drippings or icicles are melted away by tipping the blowpipe so as to undercut the edge slightly.

In making branch connections, the end of the brass pipe is first marked off. After the paste mixture is applied as a protective guide, the pipe is positioned horizontally and the melting is started at the highest point. For maximum accuracy the operator works in sections as shown on the diagram.

III. Copper-Tin Alloys—Bronzes

Relatively little welding is done on the bronzes because there are relatively few commercial applications for them in which welding is required. The process is most frequently used for making repairs.

In welding the various copper-tin alloys a welding rod similar in composition to the base metal can be used if an exact color match is desired. Otherwise, a general pur-



This Sketch Shows the Recommended Sequence of Melting Holes. As the Edge of the Hole Is Reached, the Blowpipe Is Tipped so as to Undercut Slightly, Thus Assuring a Sharp Edge

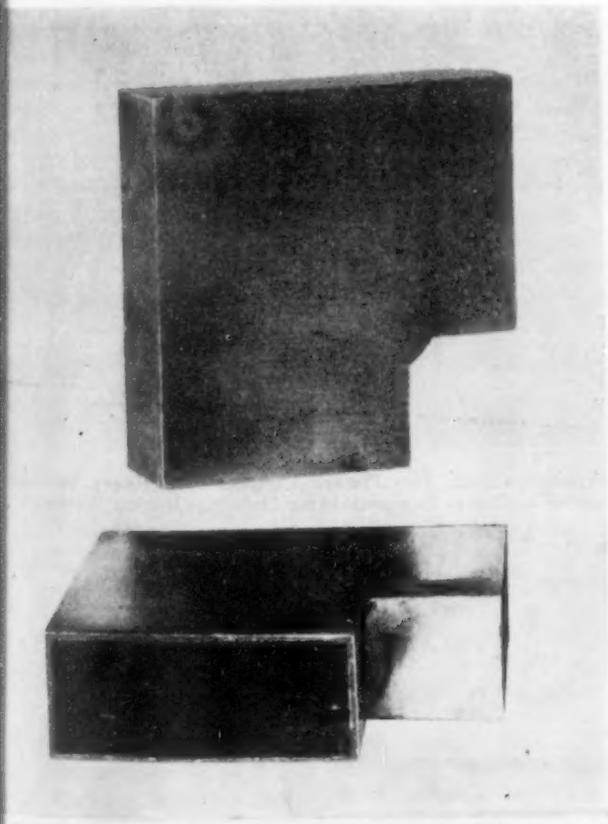
...se bronze-welding rod and a bronze-welding technique ...re used. A flux such as Brazo flux should be used. It ...applied to the weld puddle by dipping the end of the ...ated rod into the can.

...ame Adjustment for Bronze

As in the welding of the brasses, it is important to ad...st the flame so as to eliminate vaporization of the con...ituents of the base metal or of the rod and also to pre...nt boiling of the puddle. A strongly oxidizing flame ...ould be used, but the amount of excess oxygen has to ...e determined individually for each base metal.

In general, the term bronze is applied to those alloys ...f copper containing relatively high percentages of tin ...nd lead, with or without small amounts of zinc. A ...umber of miscellaneous alloys, such as those containing ...arious amounts of nickel, are also referred to as bronzes ...the nickel does not exceed 50% of the composition.

During the fusion welding of bronzes that contain rela...ively high amounts of tin, lead or phosphorus, alone or ...combination, it will be observed that these constituents ...tart melting out before the base metal has even reached ...red heat. By using a strongly excess-oxygen flame for ...oth preheating and welding, however, this tendency is ...liminated. After the base metal has melted and there is ...noticeable film on the surface of the molten puddle, the ...mount of excess oxygen in the flame should be varied ...ver a fairly wide range. As this adjustment is changed, ...t will be found that for one particular flame adjustment ...the film or coating tends to disappear and a bright sur...ace is maintained on the puddle. This is the correct ...lame adjustment necessary for good welding of these ...lloys. Usually a few preliminary trials will determine ...the adjustment; once it is found, welds free from holes ...or gas inclusions and with well-distributed tin, lead and ...phosphorus content can be made.



Extruded Brass Hollow Sections Are Usually Welded from the Top, with Minimum Reinforcement. After Finishing, the Weld Is Practically Unnoticeable

Welds in Everdur Metal Are Made with an Everdur Metal Welding Rod, Silicon-Bronze Flux and an Oxidizing Flame. Either Forehand or Backhand Technique Can Be Used, with the Forehand Method Preferred on Light Gage Stock

Rolled and Extruded Bronzes

Rolled or extruded bronzes should present no difficulty in welding because almost any of these alloys that have been previously hot-worked have good strength under welding conditions. The more complex casting alloys, however, require special care because these alloys have little resistance to hot work and to stress at high temperatures. Proper preheating will greatly assist in making sound welds and in relieving stresses in the base metal.

In parts in which there is no objection to a hairline on the surface, welding can be done from the back without veeing. The two parts are clamped tightly together, a tack-weld is made at one end of the seam, and welding is started at the other end. Where hollow sections such as doors, window sashes and similar parts are joined, welding is usually done from the front. The edges should be veed before clamping. The weld should be made with only a slight reinforcement, taking care to avoid any low spots. Attachments such as cleats, fasteners or ornaments on a frame should be welded to the individual part of the frame before assembly of the whole structure.

IV. Copper-Silicon Alloys

In addition to its use as a deoxidizer of copper and copper alloys, silicon is added to copper for the purpose of improving the mechanical properties. One of the earliest of the copper-silicon alloys is the familiar Everdur metal. Other copper-silicon alloys that have been commercialized usually include a third element such as zinc, tin or nickel. The copper-silicon alloys are weldable, they have lower heat conductivity than copper, they are not so sensitive to over-heating as are other copper alloys; and during welding a flux like, continuous liquid glass film is formed, which covers and protects the molten weld metal.

The joint design used for welding these alloys is similar to that for steel. It is recommended that thicknesses up to $^3/_8$ in. be welded in one pass, while thicker plate should be welded in two or more passes.

It is preferable to weld the copper-silicon alloys with a welding rod of a composition similar to that of the base metal. Everdur bronze welding rod and silicon bronze flux is recommended for welding Everdur metal.

Flame Adjustment and Welding Technique

A concentrated flame in a small welding puddle is best for welding the copper-silicon alloys. The liquid glass film on the molten weld metal makes it possible to use the smaller and hotter oxidizing flame without producing the detrimental effects often caused by the excess oxygen.

In general, it is preferable not to clamp the base metal tightly in jigs because most copper-silicon alloys are somewhat hot-short. A light back-up bar may be used, although by proper manipulation of the welding rod and blowpipe good fusion and puddle control can be obtained.

These alloys should be welded as rapidly as possible to keep the shrinkage stresses in the red-hot metal as low as possible. As for copper, when heavy gages are being joined, the weld should be started at some distance from the edge of the base metal and completed to one edge, returning to the start to complete the weld to the other edge. This should always be done when making the second weld of a two-pass weld, or, if for any reason the weld is to be heated again by the blowpipe flame.

In general, no aftertreatment is required on oxyacetylene welds in these alloys. The mechanical properties can be improved by hot-hammering although this is seldom done. A method that will improve the grain structure but that will probably show no improvement in ductility is cold-peening followed by complete or local annealing.

Evolution of a Railroad Well Car Constructed by Arc Welding*

C. M. Taylor†

ALTHOUGH subjected to most severe kind of punishment in actual service, well cars such as the one pictured in Fig. 1, along with other railroad rolling stock, are being turned out in ever-increasing quantities and with a minimum of time and effort due to the modern process of shielded arc welding.

While the methods used in building well cars at the Altoona shops of the Pennsylvania Railroad do not necessarily deviate from standard welding practices followed by other fabricators, it is interesting to follow the logical evolution of this structure from standard cut and shaped pieces to the finished product.

The main longitudinal members consist of the two side sill pieces measuring $2\frac{1}{4}$ in. by 6 in. and $\frac{3}{4}$ in. by 12 in., total length of each being 53 ft., 2 in.

In welding these assemblies, the parts

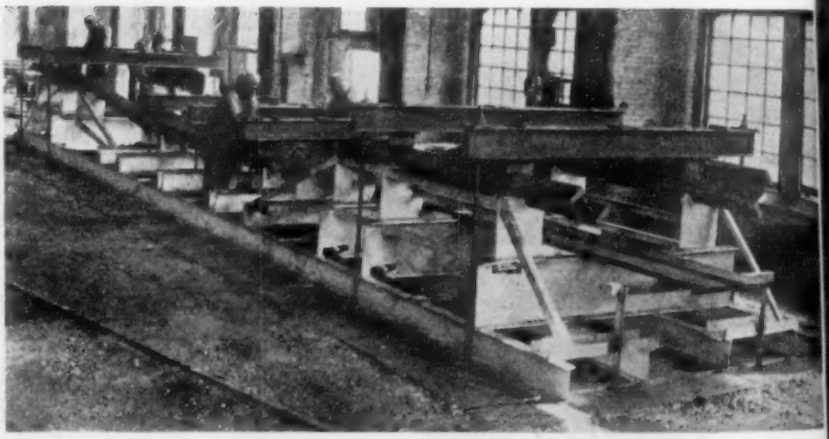


Fig. 2—Hold-down Arrangement in This Fixture Consists of 7 Heavy Members Clamped to Put Camber in Sills to Compensate for Distortion During Welding

Fig. 1—Railroad Well Car of 250,000 Lb. Capacity Produced by Modern Arc-Welding Methods

* Data and Photos Courtesy The Lincoln Electric Railway Sales Co., Cleveland, O.

† Vice-President, Lincoln Electric Co.

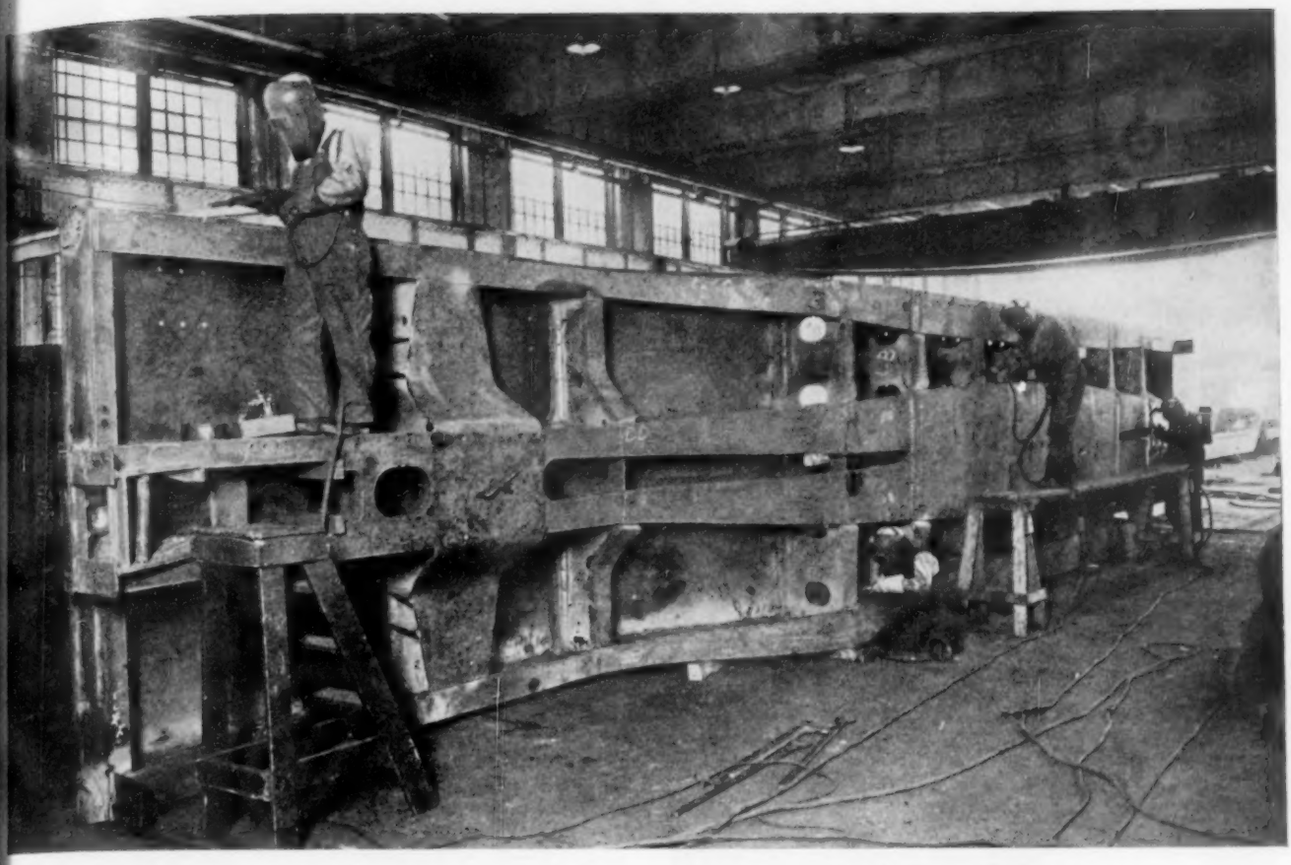


Fig. 3—Positioned Structure for Effecting Most Efficient Welding Procedure

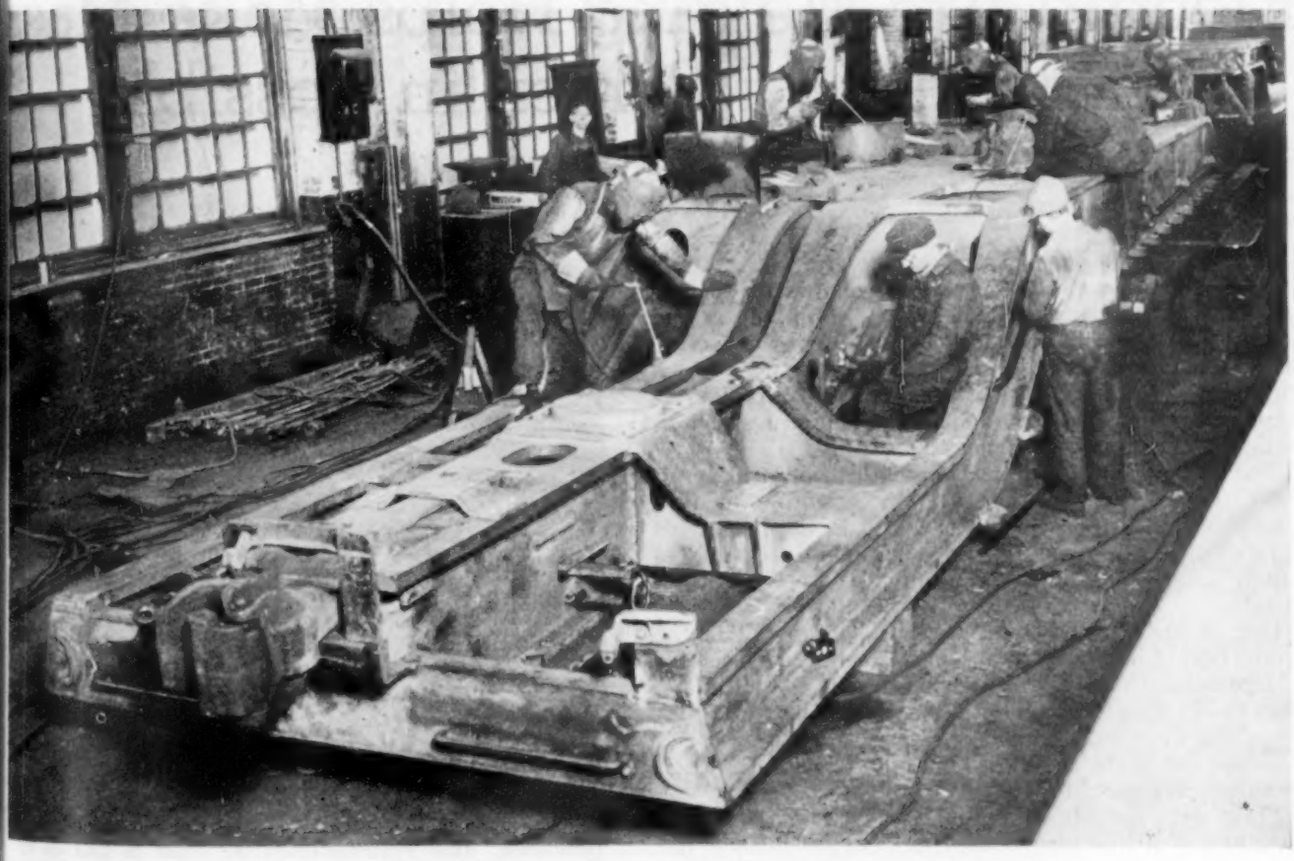


Fig. 4—Close-up of Final Welding Operations

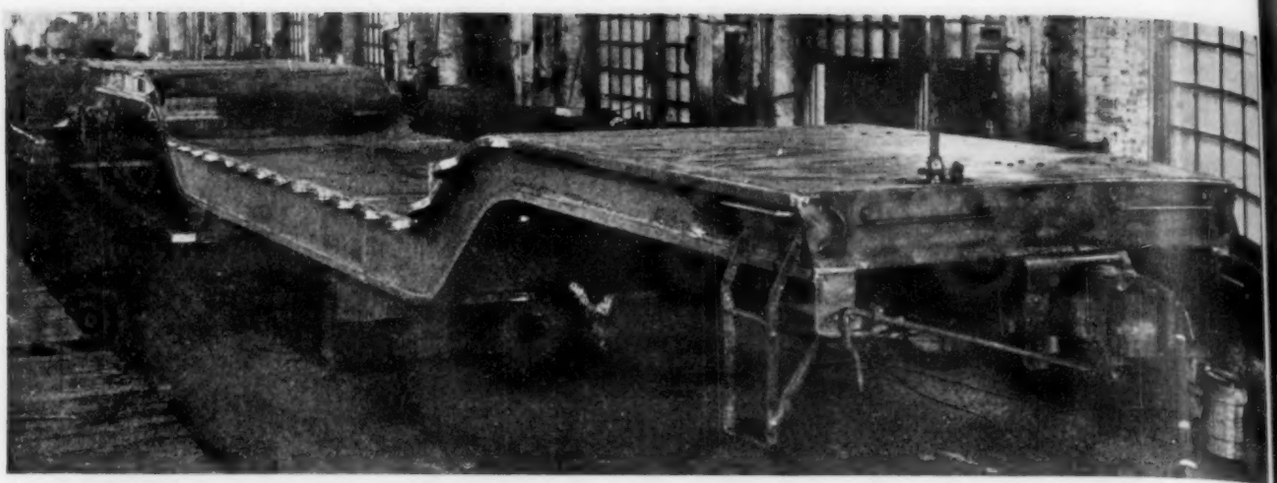


Fig. 5—All-Welded Car Frame Ready for Painting and Truck Installation

are first tacked and placed in a hold-down jig seen in Fig. 2. Here finish welding is done in two passes with a welding sequence to minimize distortion. Further precautions against undue distortion during welding are taken by putting a camber in the sill members by means of the seven horizontal cross pieces at the top of the fixture which clamp down the work. Mild steel electrode of $^{5}/_{16}$-in. size is used for this phase of the operation.

The same general fabricating procedures are used in welding the center sill. This structure is of heavier construction, the finish welded piece measuring 36 in by $2^{1}/_{4}$ in.

The car framework begins to assume its complete shape as cross supporting members are tack welded in place. Intermittent beads about 2 in. in length are applied to the $^{3}/_{4}$-in. and $2^{1}/_{2}$-in. thick cross connections.

An overhead crane positions the work on its side (Fig. 3) to effect flat and down-hand welding of all main joints. The same general procedure is used to weld the underside joints as well as the brake rigging and couplers. For this phase of the operation the unit is placed in an upside-down position (Fig. 4).

The completely welded structure, ready for installation of the trucks, is shown in Fig. 5.

Electric Arc Welding Helps Make Mass Production of Penicillin Possible

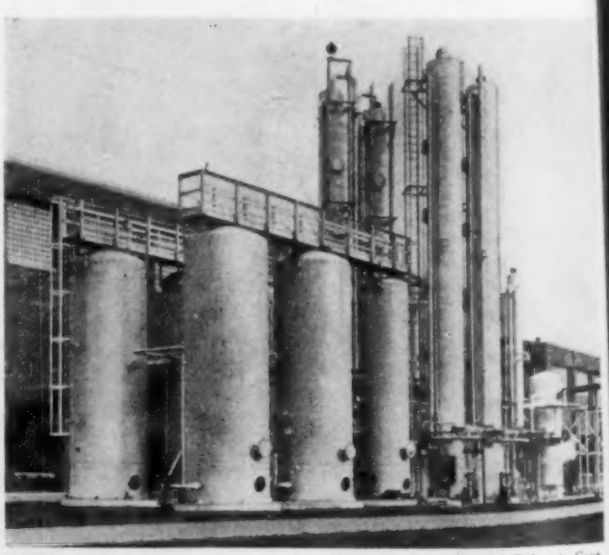
By G. G. Landis†

ALTHOUGH much emphasis has been placed on the production achievements realized in turning out ships, tanks, planes, guns, ammunition and other materials primarily designed to destroy lives, another notable phase of U. S. productive ability for which the process of shielded arc welding has also been largely responsible has been that where life-saving drugs such as penicillin are now made in mass quantities.

Today's large-scale production of this powerful germ-killer, has been made possible by scientific medical knowledge and research coupled with modern methods of fabricating the structures and equipment necessary to supply enough penicillin for war and some civilian demands.

One of the most troublesome problems posed in the production of penicillin was that of meeting the need for a large volume of the drug in the shortest possible time. This meant that a method must be found that would replace the time-consuming laboratory procedures which involved use of thousands of half-gallon bottles in which small batches were brewed.

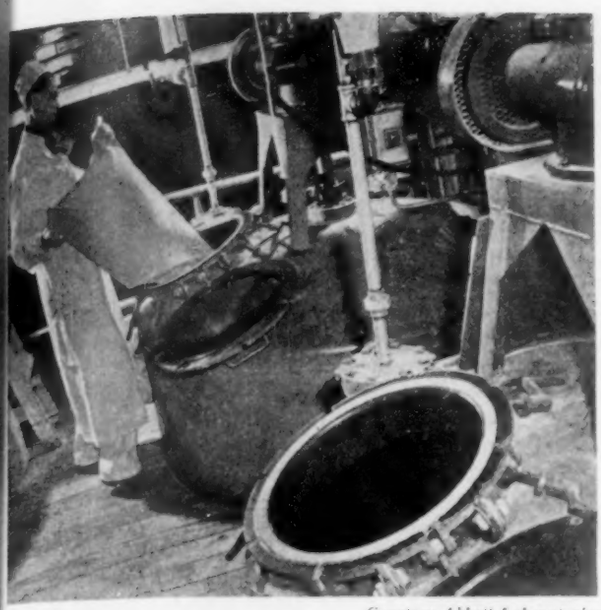
Plans were quickly formulated which called for complete new penicillin plants (see Fig. 1) approximating the



Courtesy Commercial Solvents Corp.

Fig. 1—Similar in Appearance to a Synthetic Processing Installation, This Penicillin-Producing Plant Is One of 19 Concerns Where Welding Was Utilized Extensively in Construction

† Chief Engineer, The Lincoln Electric Co., Cleveland, Ohio.



Courtesy Abbott Laboratories

Fig. 2—Adding Corn-Steep Solids to an All-Welded Tank. Structures in This Group Are Capable of Producing 4000 Gal. of Media per Day

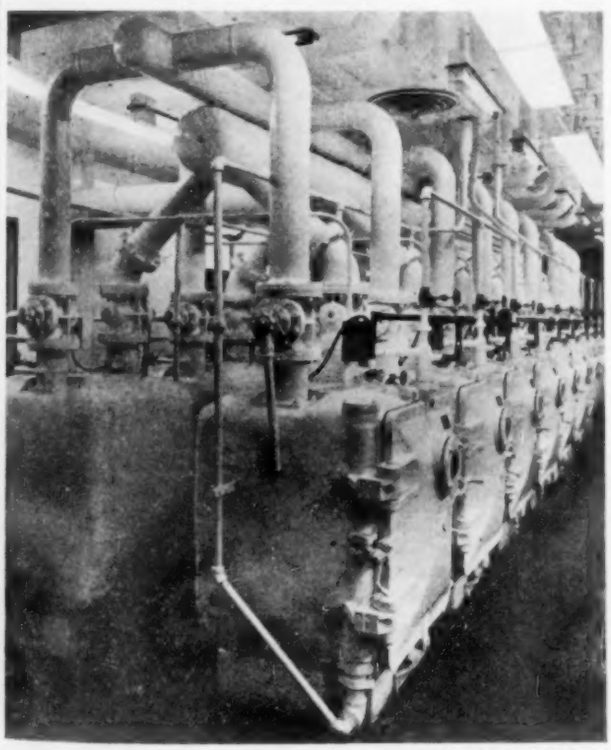
appearance of a petroleum refinery or synthetic product-producing installation. This type of fabrication required a simple, fast method of construction, yet one which would meet specific and exacting requirements. How welding fitted into this program can be judged from the fact that in some of the 19 or more plants producing the drug, approximately 90% of the metal fabrication is of welded design.

Not only was welding employed in the structural framework of the plants but the process proved to be the most suitable for the construction of all types of piping, for storage hoppers, silos, bins, conveyors, lifts, chutes and scores of other items which make up complete plant equipment.

In this connection the term "tank" includes many types and sizes of open or closed tanks, vats, gas holders and pressure vessels, some of which range up to 15,000-gal. capacity. Figure 2, for example, shows a type of tank used in producing penicillin. The all-welded vessels in this one installation are capable of producing 4000 gal. of media per day.

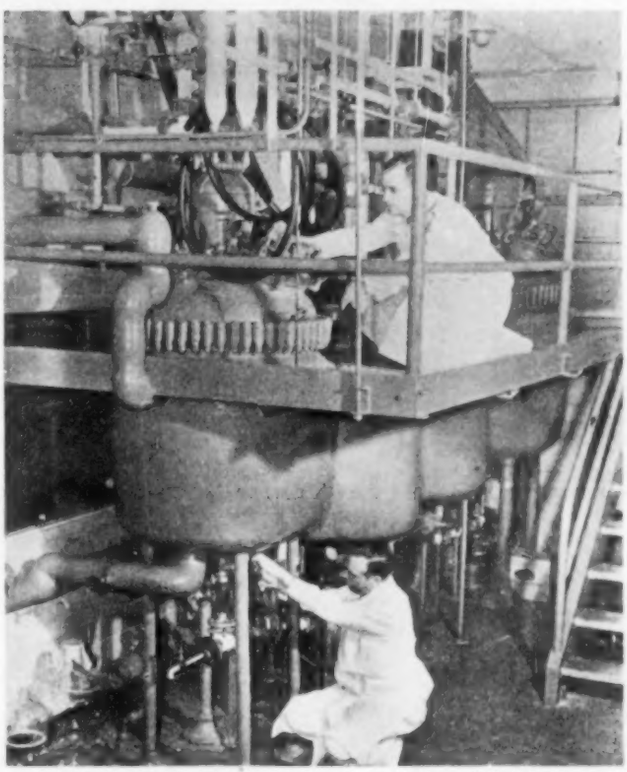
Other interesting vessels of welded construction include the dryers, Fig. 3, in which penicillin-sodium is dehydrated by low-temperature, high-vacuum sublimation. The welds in this particular vessel must be absolutely free from leaks in order to maintain the vacuum necessary to the desiccation process.

Figure 4 shows the purification room where welded extraction tanks are used in making the final sodium salt solution of penicillin. In these tanks the water is separated from the filtered penicillin solution. The extensive use of welded construction is indicated in this view by the welded stairway, railings, platform and miscellaneous pipe connections.



Courtesy National Research Corp.

Fig. 3—Dryers of Welded Design in Which Penicillin-Sodium Is Dehydrated by Low-Temperature High-Vacuum Process

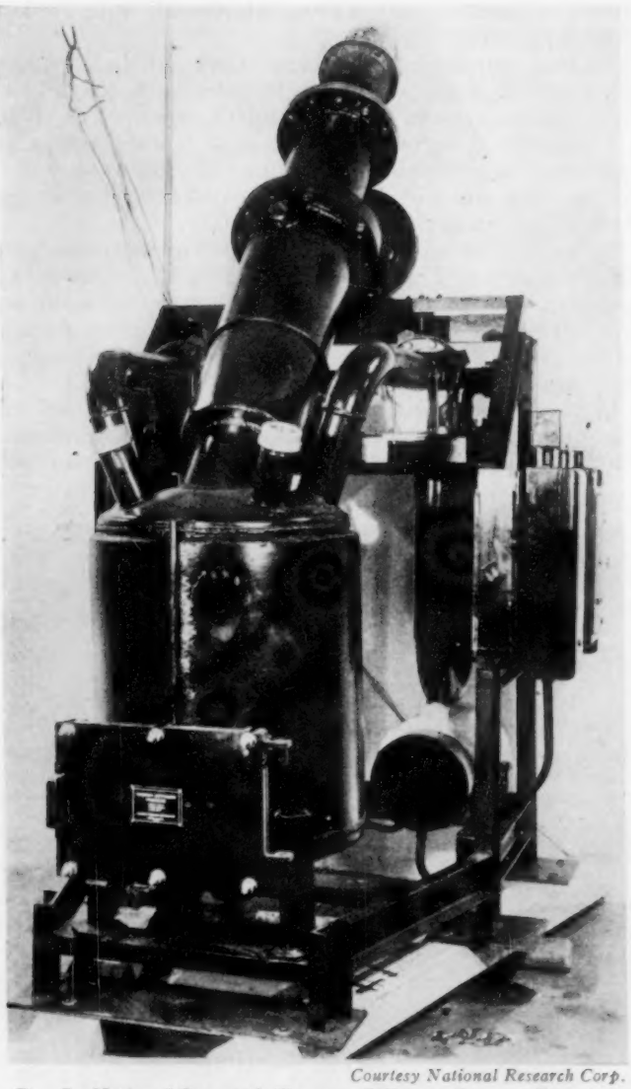


Courtesy Abbott Laboratories

Fig. 4—Extraction Tanks, Fittings, Platform, Etc., in This Purification Room Are Built by the Welding Arc

In connection with these tanks or pressure vessels, it is interesting to note that a considerable number of the joints are butt welded. For spheres and spheroids a single 60° V-groove is commonly used. The upper half of a sphere is usually welded from the outside against back-up bars tack welded on the inside to one of the abutting edges. The lower half of the unit is welded mostly from the inside, but a small groove is chipped outside into the weld metal deposited from the inside. The groove is chipped along the apex of the V, then filled by overhead welding.

Bottoms of spheroids are usually butt welded together from the top side against back-up bars or strips. Roof plates are welded in a similar manner. Side sections whether in one piece or in several sections, may be



Courtesy National Research Corp.

Fig. 5—National Research Vacuum Diffusion Process Pumping Unit Is a Typical Example of Welded Machine Design Used in Penicillin Production

welded from both sides, from the outside only, or against back-up strip on the inside.

One tank-like structure of unusual design is the all-welded National Research Vacuum Diffusion Process high-vacuum pumping unit shown in Fig. 5. This diffusion pump, built of welded steel, has a capacity of 10 lb. of water vapor per hour at 100 microns pressure absolute. Note that base, vessel body and all permanent sections of piping and fittings are solidly welded to assure absolute leakproof construction.

The adaptability of the welding arc to numerous items that are specially designed to facilitate the conveying and handling of penicillin cultures, molds, etc., used in this drug-producing process is exemplified in Fig. 6. Here special rack-type conveyors are shown which were made to exact specifications by means of welding together standard angles and shapes into one rigid integral unit. These conveyors are used to hold bottles of mold during sporulation. The operator is shown checking mold sporulation in one of the bottles taken from the handy conveyor.

Additional use of the welding process includes the fabrication of items made of both carbon and stainless steel, connecting either nipples or couplings and stainless steel tubing and for general maintenance in effecting repairs and in erecting plant additions.

Officials of the 19 principal plants in the United States which are said to produce about 95% of the world's supply of penicillin, agree that without the benefits of modern welding techniques, it would not have been possible to reach today's peak of penicillin production which is expected to soon exceed a volume sufficient to treat 250,000 serious infections per day.

The material for this article was taken from data received from the following companies: Abbott Laboratories, Chicago, Ill.; Allied Molasses Corp., Brooklyn, N. Y.; E. B. Badger & Sons Co., Boston, Mass.; Commercial Solvents Corp., Terre Haute, Ind.; Cutter Laboratories, Berkeley, Calif.; Hoffmann-La Roche, Nutley, N. J.; Merck & Co., Ltd., Montreal, Canada; National Research Corp., Boston, Mass.; Chas. Pfizer Chemical Co., Brooklyn, N. Y.; Reichel Laboratories, Kimberton, Pa.; The Upjohn Co., Kalamazoo, Mich.

Courtesy Abbott Laboratories

Fig. 6—Numerous Items of Plant Equipment Such as This Rack Conveyor for Penicillin Mold Bottles Are Easily Built to Specifications by Arc Welding

Failure of Spherical Hydrogen Storage Tank*

By A. L. Brown† and J. B. Smith†

ON FEB. 16, 1943, at 2:47 P.M. eastern war time, a spherical hydrogen storage tank, 38.5 ft. in diameter, located beside the gas generator building, General Electric Co., Schenectady, N. Y., failed structurally with explosive violence. The sphere was made of welded steel plate, and materials, design and erection were in accordance with the A.S.M.E. Code. The tank was designed for a working pressure of 50 psi. and contained hydrogen gas at about 50 psi. gage pressure. It was protected against normal excess pressure by two 2-in. relief valves. One of the valves, not seriously damaged by the accident, was tested with air and found to open properly at from 53 to 58 psi. gage.

Immediately preceding the accident there was a 36-hr. period of subzero temperature, following which the thermometer rose about 27° F. in 7 hr. and was about 10° F. when failure occurred. At this time the sun was shining on a point about diametrically opposite the manhole.

The generally excellent quality of the welding is demonstrated by the fact that only a few feet of fracture followed the many feet of welded seams. It is significant also that the fractures did not involve, except in a minor way, the support-leg attachments where there are concentrated stresses due to the loads from the dead weight of the sphere.

Occurrence of Fractures

The sphere burst into about 20 fragments (Fig. 1). Each piece was surveyed, and using the welds as reference lines, all fractures were plotted to scale on a model sphere 15 in. in diameter. An inspection was also made of the characteristic "herringbone" markings (Fig. 2),

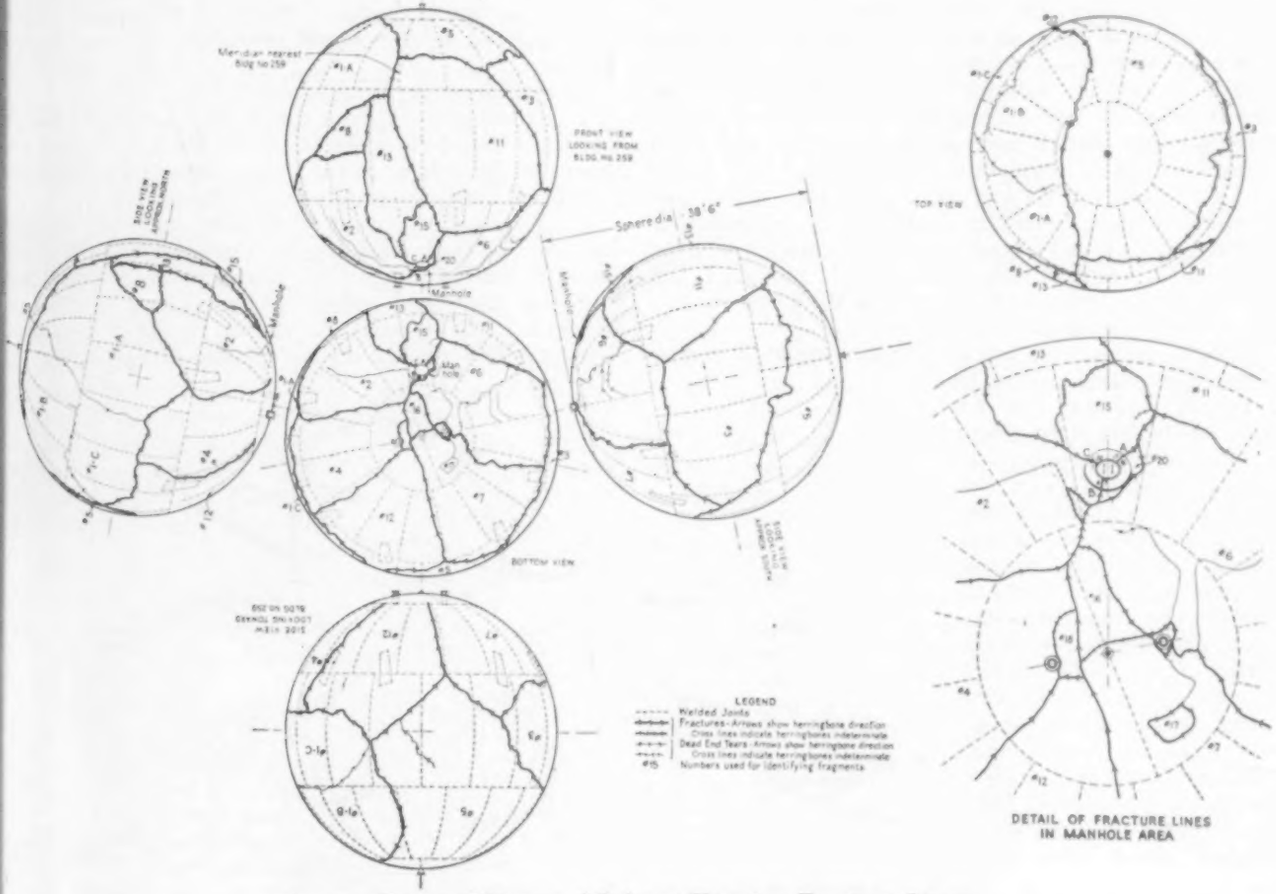


Fig. 1—External Views of Sphere Showing Fracture Lines

* Reprinted from June 1944 issue Mechanical Engineering.

† Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

A subcommittee, appointed by the A.S.M.E. Boiler Code Committee, is reviewing the accident described in this report as well as other related experiences. If the causes of the accident can be avoided by changes in the rules of the A.S.M.E. Unfired Pressure Vessel Code, this committee will offer suggestions to the Boiler Code Committee. For this reason, recommendations contained in the Associated Factory Mutual Fire Insurance Companies' report, which would directly involve changes in the Code requirements, have been omitted from this article.—EDITOR *Mechanical Engineering*.

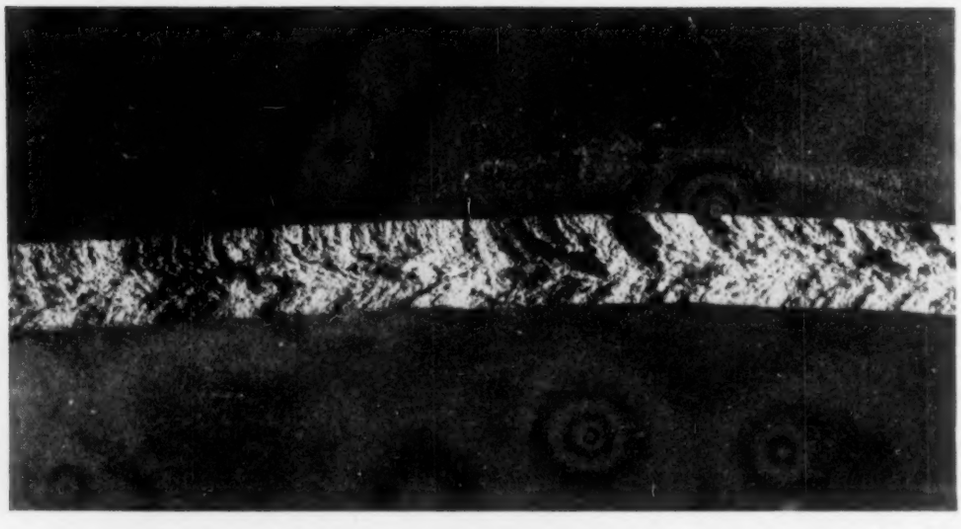


Fig. 2—Typical "Herringbones" on Fracture Edges
Arrows formed point toward origin of tear.

indicative of the direction of tearing, on both edges of the total of 650 ft. of fracture; and arrows showing the actual herringbone directions were drawn on the fracture lines. This synthesis indicated that failure began at the 20-in.-diam. manhole neck. The arrows shown on the fracture lines (Fig. 1) point in the direction of the "herringbones" which themselves point toward the tear origin. From the manole the tears radiated over the entire surface, almost instantaneously, releasing the fragments, which were blown into their final resting places by expansion of the compressed hydrogen. The intensity of failure was greatest near the manhole and in the bottom cap.

Reasoning from convex and concave bends found in the manhole cover, the failure originated at point *C* (Figs. 1, 3, 4 and 5), in an incipient crack in the sheared inside edge of the neck where plate shears had left a torn surface. From *C* a fracture ran to the left (facing the manhole, Fig. 1). Also along this line a bulge from internal pressure started and produced second and third fractures at similar incipient cracks in the neck at *A* and *B*. The initial movement produced the slight but noticeable convex cover bend (Fig. 5). Immediately following, the fractures freed fragments 15 and 2, and the remote ends, moving radially outward, produced the marked concave bend in the cover and the failure of the bolts by combined tension and shear.

In the meantime, the fractures beginning at *B* and *A* had run, respectively, down to the left of fragment No. 12, and up to the left of fragment No. 11 across the pole caps to the junction at the top of No. 12. This formed the first complete circumferential fracture dividing the sphere in two hemispheres. The final resting places of the fragments supports this reconstruction of the progress of the failure which proceeded so rapidly, because of the self-producing-shock character of the breaks, that almost complete fragmentation occurred before anything more than the initial acceleration of individual pieces was under way.

The fragment locations also indicate that fractures nearest the manhole separated first in a manner which caused the sections to hinge more or less about their "trailing" edges. This accounts for their landing slightly off the extended radii joining their centers with the center of the sphere. The minimum hinging would be expected where the first fractures, having the highest velocities, developed; this is found to be true of the fragments nearest the manhole and also of Nos. 11 and 12, which must have been among the first to separate since they were thrown furthest by internal pressure.

All eight anchor bolts attaching the V posts to the footings were sheared outward. Three of the four welded support base plates were torn from the V posts. Three of the V posts remained attached to sphere fragments.

The Cause

On the basis of available information, this sphere is the only one of about five hundred already installed to fail structurally while in service. Although, at first, appearances indicated that an internal-combustion explosion had occurred, this theory was not supported by the evidence.

It was concluded that the structural failure resulted from the accidental coincidence of a number of factors, each unfavorable to the stability of the sphere, which, if considered singly, would probably not have seemed serious.

The unfavorable factors included:

1. A stress level, from the normal internal hydrogen pressure, that was higher at the manhole neck than elsewhere in the sphere owing to the stress-raising effect of the 20-in. opening, despite its reinforcement.

2. Residual stresses of yield-point values in the same location due to the shrinkage of the large amount of weld metal deposited in the joint between the manhole neck and the reinforced sphere plate. These stresses are believed to be triaxial, as shown in detail in Fig. 3. They would seriously restrict plastic flow necessary for

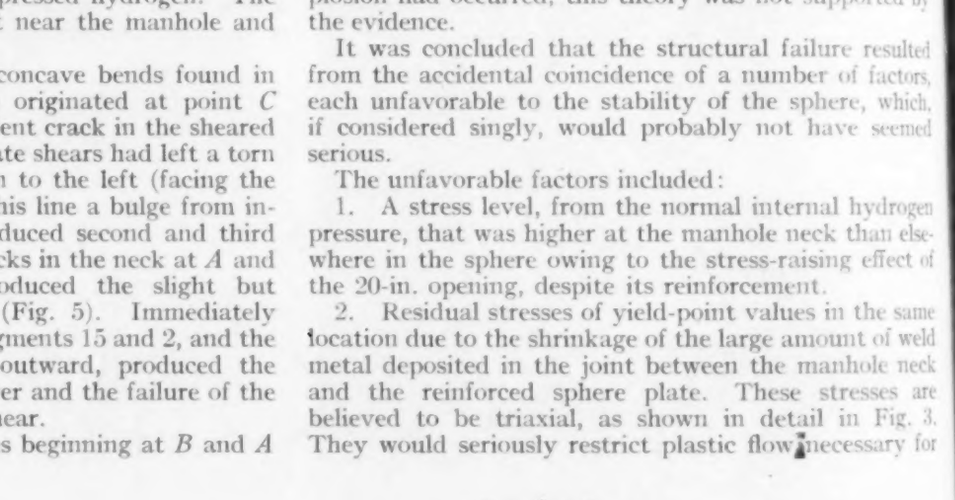


Fig. 3—Location of Manhole Fractures

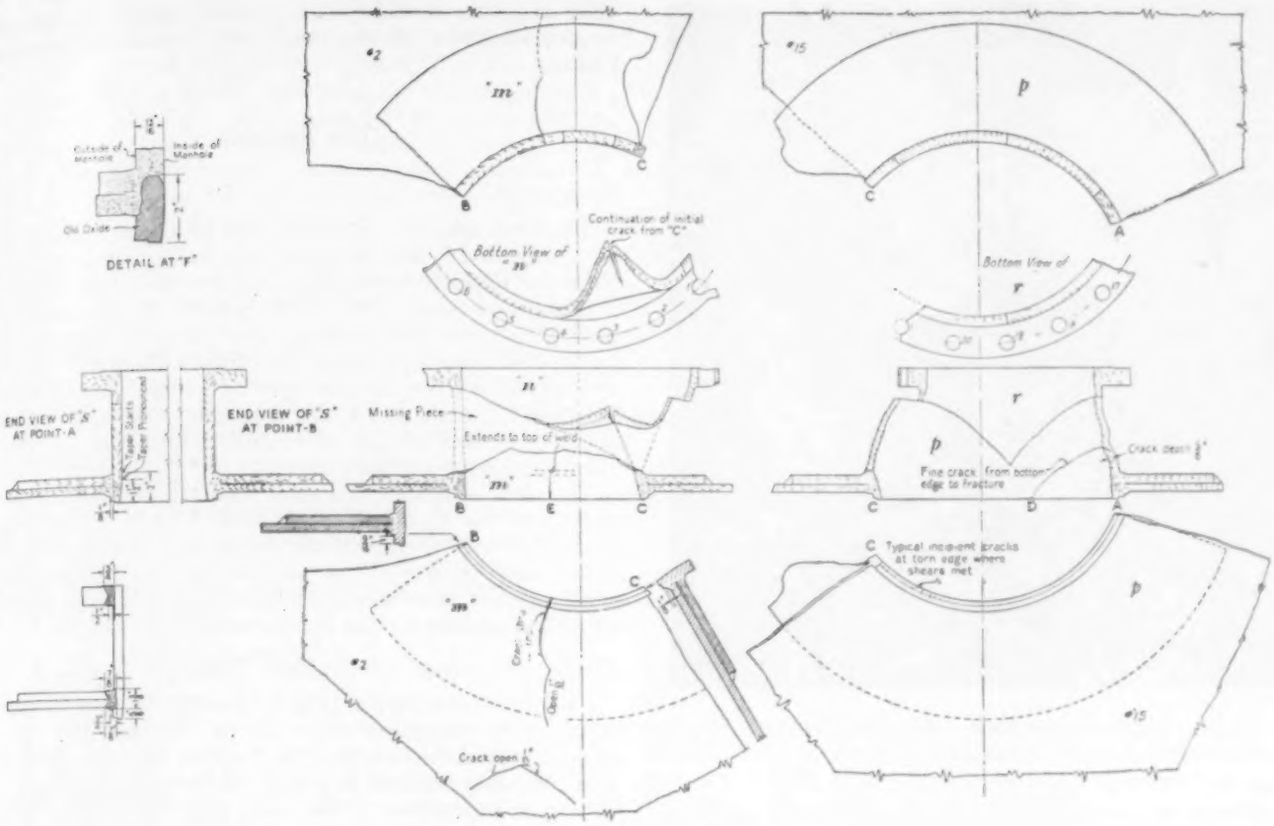


Fig. 4—Details of Manhole Fractures

self-relief of the stresses so that failure could occur after relatively little additional stress.

The inner edge of the manhole neck was deformed radially outward up to $^1/_8$ in. by shrinkage stresses from welding (Fig. 4) which showed that the metal at this location had been stressed above its yield point and retained yield-point stresses except where partly relieved by local cracking.

Attesting to the severity of these stresses and the restricted plastic flow was the apparent presence before the accident of one large radial crack, and possibly others, in the manhole neck adjacent to the aforementioned weld. These cracks are discussed later in this article.

3. The greatly increased brittleness, under the low-temperature conditions, of the particular grade of welded plate used, when notched as by cracks and when exposed to a relatively slight shock. This characteristic was established by Charpy impact tests on samples cut from the failed sphere and is a well-known property of the semikilled steel involved. In addition to the brittleness of the plate were the biaxial stresses from the internal pressure which are equal in both directions throughout a sphere. These factors, combined with the large amount of energy available from the compressed gas as compared with water, resulted in the continued progress of initial fracture into many tears which separated the sphere plate into a number of pieces that were thrown forcibly outward.

4. The probable occurrence of some type of shock imparted to any part of the sphere. This may have been the formation of another crack, similar to the one at *F* (Figs. 3 and 6), as a result of increasing hydrogen pressure caused by the rapid rise of outdoor temperature and the sun's rays; or possible increases in plate stresses, particularly in the area around the manhole, due to uneven heating by the sun's rays of portions of the sphere, or, in view of the unusually cold weather, to frost shock transmitted through pipe connections or support legs from the frozen ground.

Description of Sphere

The sphere plates of steel 0.66 in. thick were arranged in five zones corresponding, from top to bottom, to the Arctic, North Temperate, Torrid, South Temperate and Antarctic zones, into which the earth's surface has been arbitrarily divided. The Arctic and Antarctic zones contained two plates each; the other three zones, 16 plates each. The vessel was designed in accordance with Par. U-69 of the A.S.M.E. Code for Unfired Pressure Vessels for a maximum working pressure of 50 psi. based upon an allowable unit working stress of 11,000 psi. and a weld-joint efficiency of 80%.

The plates were shop-formed cold and were erected in the field by the builder of this spherical container during September and October of 1942. The joints were arc welded. Covered electrodes were used in welding. In line with Par. U-69 of the A.S.M.E. Code, neither the completed vessel nor any part of it was stress relieved after welding.

The sphere stood on four concrete footings which were carried 5.5 ft. below grade. From each footing, two steel-angle support legs diverged and were welded to support pads symmetrically spaced around the horizontal seam, just below the Torrid zone. At the point of attachment the supports were tangential to the sphere.

The sphere was tested with air pressure at 62.5 psi. gage for about one hour on Oct. 10, 1942. After the test the pressure was dropped to 50 psi. and no leaks were found when the welds were covered with soap solution. Several days prior to October 10 the vessel had been hammer-tested by the erector's workmen while it was

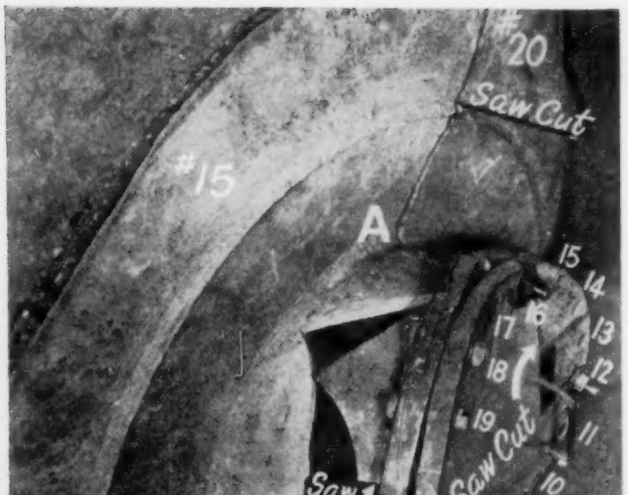


Fig. 5—Double Bend in Manhole Cover
Reassembly of fragments except No. 2

filled with air at atmosphere pressure. It was placed in service about the middle of December 1942.

Improbability of Internal Explosion

Immediately following the accident, a careful study was made to determine if an internal-combustion explosion of hydrogen-air or hydrogen-oxygen mixture had occurred. This included a study of: the sphere history following installation; the detailed method of hydrogen generation and purity tests; low-, intermediate-, and high-pressure pumping and storage systems; operating practice and safety precautions at the gas plant; and a thorough examination of evidence and test of equipment remaining after the accident.

The simultaneous occurrence of a source of ignition and a mixture of air or oxygen with the hydrogen, within the limits of inflammability, would have been required to have an internal-combustion explosion.

The report on which this article is based covers the details of the hydrogen system, the possibilities of ignition of an explosive mixture, whether or not such a mixture could have been present, and what evidence there was that the failure was caused by internal-explosion pressure. The theory of internal explosion is not supported by the evidence.

Calculations indicate that there was sufficient energy from the expansion of the compressed hydrogen alone, if wholly applied to raising the 65-ton sphere, to lift it about 1800 ft.; this would provide many times the energy needed to throw all the fragments to their final resting places.

The Manhole

Description

The manhole, Fig. 7, where the failure is believed to have originated, was designed and welded in accordance with the Code requirements and common practice. It consisted of four parts. The bolting flange and neck constituted one subassembly, and the reinforcing collar and sphere plate comprised the other. Each was welded at the builder's shop and shipped to Schenectady. On the field site the neck and flange assembly was joined with a very heavy weld to the plate and collar assembly while both were lying on the ground.

The neck consisted of a strip $^{3}/_{4}$ in. thick, sheared 9 in. wide, and cut to a length of about $5^{1}/_{2}$ ft. This strip was rolled into a ring 20 in. inside diameter and joined in the shop by a vertical butt-welded joint. The bolting flange was then welded in place and machined to give a finished surface for the cover gasket.

Residual Shrinkage Stresses from Welding

As would be expected, the field weld, for which many passes were necessary in order to deposit the large amount of weld metal, produced severe thermal stresses. These stresses resulted in plastic deformation and potential crack formation in the neck (Fig. 4). The inside circular edge of the neck projected from $^{1}/_{8}$ to $^{5}/_{8}$ in. above the weld into the sphere. In some places this edge was bent outward $^{1}/_{8}$ in. so that the diameter at the inside edge was approximately $^{1}/_{4}$ in. greater than the normal-diameter neck (Fig. 4).

The metal in the neck next to the weld was probably under triaxial stresses. This stress condition would greatly restrain the flow of the metal under yield-point stresses upon which ductility depends. The three different stresses would be (see Fig. 3): (1) the normal horizontal hoop tension; (2) the horizontal radial tension in the neck from shrinkage of the surrounding sphere plate away from the neck; and (3) vertical surface ten-

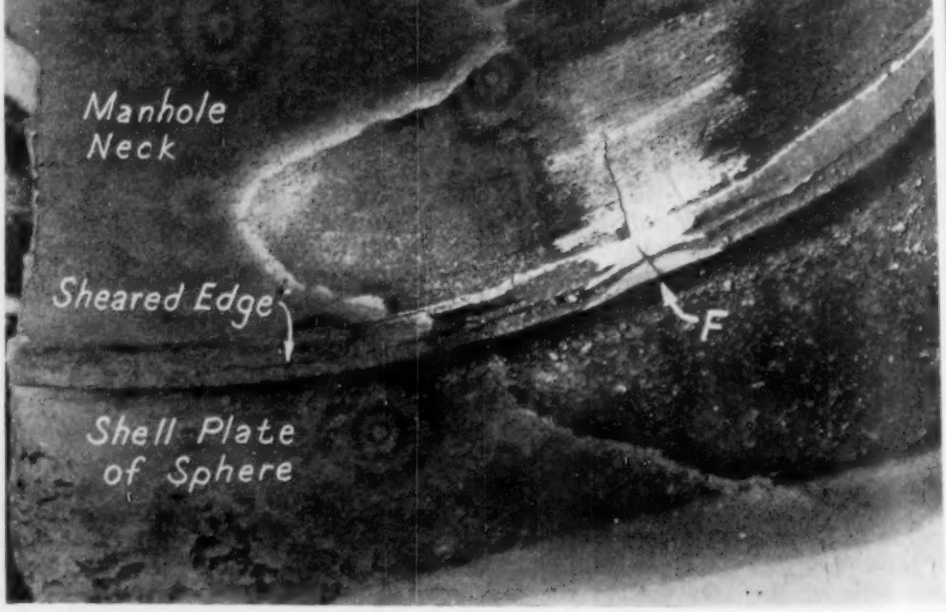


Fig. 6—Old Crack at *F*, Fig. 3, in Inside Edge of Manhole Neck After Buffing and Magnaflux

sion parallel to the neck axis caused by shrinkage of the large weld on the outside. The directions of these stresses are indicated in Fig. 3. The reduced ductility under triaxial stresses probably accounts for the crack mentioned (*F* in Fig. 3). When pressed open in a testing machine to expose the inside surfaces, the crack was found to be completely covered with a dark brown oxide which indicated that it was old and probably had been present prior to the failure of the sphere. However, the manhole fragments were exposed to the weather for about three weeks prior to careful examination. The crack could have occurred at the time of cooling following the weld or, even more likely, under the combined residual cooling stresses and the added stresses produced by the test pressure. It seems likely that the crack did not proceed beyond the multiaxial highly stressed zone at the time, because it occurred while the metal was at normal temperature and not under the cold brittle condition.

Two other unopened cracks, *D* and *E*, were found and were forced open for inspection. These were only partly oxidized and were light reddish in color, which showed that they were new and had probably been caused by the accident.

Sheared Edge of Manhole Neck

Three main vertical fractures (designated *A*, *B* and *C*, Fig. 3) were found in radial planes in the neck, as well as two new (*D* and *E*) and one old crack (*F*), already mentioned, which did not become fractures. The vertical fractures branched into horizontal fractures between the bolting flange and reinforcing ring, so that two pieces (*n* and *r*) of the bolting flange separated from the neck. The herringbones on all the vertical fractures and cracks indicated that they originated at the inside edge of the neck.

This inner edge of the neck (Fig. 4), left in the "as-sheared" condition, had a $^1/_{16}$-in. step with a rough torn corner. When this edge was buffed and treated with Magnaflux, many minute incipient cracks from $^1/_{16}$ in. to $^1/_2$ in. in length and from $^1/_{64}$ in. to $^1/_{32}$ in. deep were found. There was about one such crack in every inch of edge perimeter. While obviously none of these incipient cracks, evident after the accident, was actually involved in the failure, others like them probably provided starting points for the three fractures and the three cracks mentioned. It is well known that such incipient cracks will act as "stress raisers" and provide points of origin favorable to the formation of the larger cracks and fractures.

Stresses from Internal Gas Pressure

The 20-in. manhole was more than twice the diameter of the next largest opening in the continuous skin of the sphere. Although the opening was designed in accordance with the A.S.M.E. Code, and was reinforced by an annular ring, 7 in. wide and $^5/_8$ in. thick, and a portion of the neck itself, stress studies in other vessels with similar reinforced openings in which actual strains have been measured by means of gage points show that the stress in the plate adjacent to the manhole, resulting from internal gas pressure, could have been expected to be appreciably higher than at any other point in the sphere.

Cumulative Effect of Stresses and Sheared Edge

It is therefore apparent that excessive stresses from thermal contraction after welding were present as evidenced by neck deformation. These stresses, added to the stress from the internal gas pressure, and atmosphere temperature conditions in the presence of the rough sheared edge with its many incipient cracks adjacent to the weld combined to favor the formation of large cracks which would seriously affect the safety of the structure, especially when subjected to a shock. It is therefore likely that the three main vertical fractures in the manhole had their origin at the incipient cracks in the unfinished edge, and there is a strong possibility that one of these incipient cracks had, at the time of accident, developed into a crack comparable in extent to the one found with the dark brown oxide coating and that this was the trigger setting off the rapid progressive failure under the brittle plate conditions.

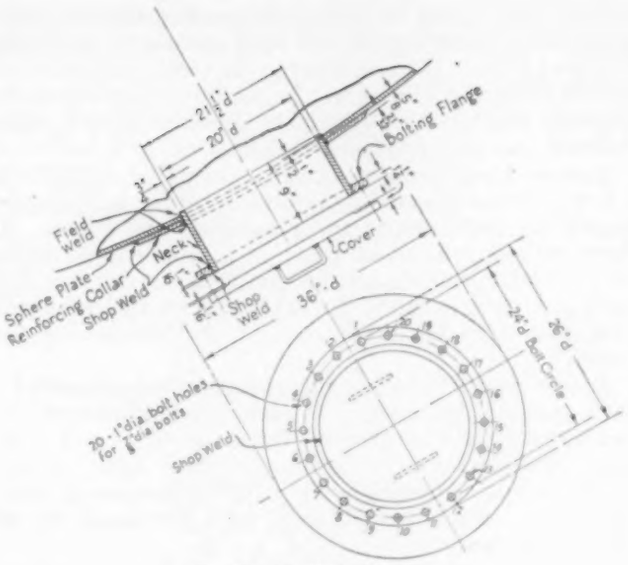


Fig. 7—Manhole Design

Conclusions

The character of this failure was due chiefly to the brittleness, under the conditions existing at the time, of the steel plates from which the sphere was constructed. Such brittleness, as shown by notched impact tests of the steel at corresponding temperatures, combined with stresses of a character (multiaxial) which restricts ductility and favors a brittle type of fracture, brought about a characteristic fragmentation or a rupture into a considerable number of pieces with the fractures showing little evidence of the reduction in area or shear which would be present with a simple tension failure. Much more extensive fracturing of this type can occur from the expenditure of a given amount of energy than if the breaks were of the more frequently experienced unidirectional tension type occurring in plate of normal characteristics.

Failure by extensive fragmentation may give an impression of the existence of energy unusual in character or amount, but such is not necessarily the case. With the great amount of total energy stored in compressed gas and with its potentially rapid rate of release, complete rupturing of some type may result. The external damage is a consequence of the liberation of great energy rather than of the type of fracture of the container

Neither a low value of notched impact resistance nor the existence of multiaxial stresses reduces the actual ultimate tensile strength of the steel. However, the former leads to the occurrence or spread of fractures under exposure to shock while under stress, whereas the same stress and shock conditions would not produce such extensive fracturing in the case of a more ductile steel. The latter condition, by diminishing the ductile flow of metal, has the effect of raising the yield point to

values approaching the ultimate strength, thereby interfering with a reduction of high local stresses by stretching in the vicinity. If stresses up to the yield point have occurred, they will remain at a value not safely below the ultimate strength. A relatively small additional stress or shock can then produce a failure.

This accident demonstrates that the use of steel having a low notched impact value at operating temperature favors the development and progress of the failure. It therefore seems a sound move in a practical direction, when constructing vessels of this type, to call for steel having a good notched impact value at the minimum temperature to be anticipated at the location of the vessel.

It is important that, in the design of structures which have considerable energy available for self-destruction and serious external damage, the metal be of good ductility, and also that indeterminate high local stresses produced by fabrication or by poor distribution of working stresses be eliminated, or at least minimized, by all practical measures.

In a non-stress-relieved pressure container, residual stresses of uncertain magnitude can remain after welding, especially at points of complicated stress arrangement. This possibility exists even with the best quality of welding, carefully developed welding procedure, and the use of high-grade, ductile, base metal.

Even though experience has shown that only a very few such structures have failed, the extreme danger to life and property emphasizes the importance of avoiding high residual stresses by methods of proved effectiveness.

Owing to the serious consequences of failure of a gas container under pressure, as demonstrated in this case, a maximum air test pressure of only one and one-quarter times the working pressure was applied to this sphere following its completion.

Its value in disclosing defects which are serious structurally or in contributing materially to stress relief may well be questioned in view of the proportionally larger variables introduced by working conditions. Obviously its adequacy is not comparable with the generally advised and accepted hydraulic test at double the working pressure. Despite the increased cost over vessels not tested in this way there is no apparent sound reason for accepting an uncertain low factor of strength in this hazardous type of equipment.

Manholes should be designed so that weld metal will be deposited where complex or multiaxial stresses will be avoided as far as possible. Reinforcement around manholes or other large openings should be designed and fabricated in conjunction with the manhole to give a unit which will redistribute safely the stresses which would otherwise be carried by the shell of the vessel.

All welds at manholes, nozzle connections and at the point of attachment of supports should be made in the builder's shop. Following this, the assembly consisting of the detail and the plate to which it is attached should be stress relieved by drawing in a furnace. Finally, the subassemblies should be treated with magnetic substance and magnetized (Magnafluxed) in order to detect cracks.

The inside edge of manhole necks and other nozzle connections, or similar parts, should be finished smooth so as to remove all surface cracks. Absence of cracks should then be checked by Magnaflux treatment.

Piping connected to a sphere should be designed with sufficient flexibility to prevent transmission of shock or stress to the shell.

In the case of tanks already erected and having manholes of a design similar to that involved in this accident, the minimum additional attention which should be given to checking potential weakness is to Magnaflux the entire manhole region at the earliest time convenient for releasing pressure, and, if necessary for safety, purging the vessel with inert gas or air.

If any cracks are disclosed, the plate containing the manhole should be cut out and carefully replaced by a manhole and plate subassembly as suggested in the preceding paragraphs. However, if the cracks are small they might be removed by grinding without impairing the strength of the structure.

EDITORIAL NOTE: As usual where there is lack of exact quantitative information, those engineers concerned with safety will lean heavily on the conservative side. Some of the statements and precautions implied as absolutely necessary have yet to be demonstrated as necessary and conversely that they will provide the desired safety measures. Attention is called to needed research in this field and those people interested should communicate with the Welding Research Council, 29 W. 39th St. New York 18, N. Y.

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(Continued on page 264)

Production Problems and Production Control*

By E. C. Brekelbaum†

UP TO the present time welded fabrication, for the most part, has been competing with cast or riveted or forged construction. In most of these cases, it was comparatively easy to show savings even though the welding practices in use left much to be desired.

In the future, however, with welding and welded products competing against welding and welded products, costs will be a major factor. Haphazard welding practices must give way to complete and efficient welding procedures and control.

Most companies engaged in welding are at a loss as how to arrive at the most efficient methods because welding is performed by a complexity of manual operations—operations where the human element is a tremendously powerful influencing factor. As a result, they have relied upon one of the following three standard basic methods of computing wages:

Piece-rate method.
Day-rate method.
Base-rate-plus-premium method.

Our plant at Milwaukee where all-welded overhead cranes, electric hoists, and excavators are built, both the piece-rate and the day-rate welding systems were formerly used. Eight consecutive years were spent operating under piece-rate and three years under the day-rate method.

Close analysis clarified the advantages and disadvantages of both methods and showed the need for a more appropriate system. In the ensuing years, we developed and applied a new production welding system (based on the base-rate-plus-premium method of compensation) which does precisely what its name implies—it provides a complete control of all phases of welded fabrication. It employs the use of Arc Timers and Recorders which will be explained later in the paper.

How the Production Welding Control System Applies to the Various Methods of Compensation

It should be clearly understood that any of the three basic methods of compensation can be used in conjunction with the Production Welding Control System. It is not absolutely necessary to change an existing method. Whichever method is used, its inherent values can be greatly enhanced. On a comparative basis, however, we have found that there are more advantages to be gained from the base-rate-premium method than from either the piece-rate or day-rate method of compensation. Those disadvantages that can be corrected when the basic method is used as a functional part of the Production Welding Control System are also outlined.

The Disadvantages of the Piece-Rate Method of Compensation When Operated by Itself

1. It is difficult to check as to whether the actual amount of welding done (arc time) is equal to the amount called for to do the job properly,
2. There is no control over the welding heat being used.
3. Skimping on the size of welds is possible.
4. Choice of size and type of electrode can be abused.
5. There is no check against "bridging" or including foreign materials to fill the weld.
6. Quality is sometimes sacrificed for speed.
7. There is a tendency to use over-size electrodes.
8. A great amount of supervision is necessary.
9. There is no control which insures a fair return to each workman on a group welding job.
10. There is no control whatever of actual welding time or cost if the original time study is out of line.

When the basic piece-rate method is used with the Production Welding Control System, all but items 9 and 10 of the disadvantages can be corrected. Items 9 and 10 are controllable only under the base-rate-plus-premium method of compensation.

NOTE: Although piece-rate (assuming the original time study is right), provides an accurate control of cost and production, it involves a total administrative or overhead cost that is approximately 50% greater than the other two methods. Because the piece-rate method invites hurried, careless work, welding procedures are difficult, if not impossible to control.

Under piece work in welding, you have definite cost control—if. If you have made the proper job time study, the job will cost the same every time it is run providing nothing unusual happens, whereby, the operator falls below his daywork performance. In such a case, most plants pay him his day-rate anyway. The cost might exceed the original amount slightly at times, but under normal circumstances you will get the job for the same amount every time it comes through.

Piece work has functioned very satisfactorily on many production applications like machining and other operations because the factors involving cost could all be definitely determined. In these cases, when a time study is made, the factors are all set down and a definite cost is established. The machine operator cannot vary the factors and therefore stays well within the established cost. This is not true in welding, however. In welding, there are so many varied factors involved to throw the original time study out of line that almost anything can happen. Following is just one little example to illustrate this.

Let us take a welding job on which a time study is being made, and you have included the proper allowances to determine the cost. Suppose you have a job that has 100 ft. of $^1/_4$-in. fillet and you weld with $^1/_4$-in. E-6010 electrode. Everybody knows it is most difficult for even the best of welders to hold the $^1/_4$-in. weld size right down

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Table 1—Theoretical Arc Time Chart for Class E-6010 Electrodes for Fillet Welds

Fillet Size	Size Electrode	Lbs. in Ft. Commercial Fillet	Actual Deposition Rate		Arc Time Per Ft. Weld	
			Min. lbs./hr.	Max. lbs./hr.	Min. hrs./ft.	Max. hrs./ft.
1/8"	1/8"	.0292	2.03	2.30	.0127	.0144
5/32"	1/8"	.0552	2.03	2.30	.0239	.0271
5/32"	5/32"	.0552	2.93	3.20	.0172	.0188
3/16"	1/8"	.0659	2.03	2.30	.0287	.0325
3/16"	5/32"	.0659	2.93	3.20	.0206	.0225
3/16"	3/16"	.0659	4.03	4.52	.0146	.0163
7/32"	5/32"	.0894	2.93	3.20	.0279	.0305
7/32"	3/16"	.0894	4.03	4.52	.0198	.0222
1/4"	3/16"	.1169	4.03	4.52	.0259	.0289
1/4"	1/4"	.1169	5.14	5.70	.0205	.0227
5/16"	1/4"	.1824	5.14	5.70	.0320	.0355
5/16"	5/16"	.1824	7.92	8.90	.0205	.0231
3/8"	1/4"	.2628	5.14	5.70	.0462	.0512
3/8"	5/16"	.2628	7.92	8.90	.0295	.0332
1/2"	1/4"	.4665	5.14	5.70	.0819	.0908
1/2"	5/16"	.4665	7.92	8.90	.0524	.0590
3/4"	1/4"	1.051	5.14	5.70	.1843	.2040
3/4"	5/16"	1.051	7.92	8.90	.1180	.1328

to a minimum, all the time. He has to have a certain amount of leeway. Many companies give him a leeway of 1/16-in., but even to keep it down as small as possible, you certainly must allow 1/32-in. variation. So, during the time study, we will see that he puts down a 9/32-in. fillet using an electrode on a low heat range. You find, from the time study, he was depositing the metal at 5.2 lb. per hr. (see Table 1). The operator performed very satisfactorily. He held the weld within 1/32-in. of the qualified size and used the electrode that was in the heat range as set up for the job.

Now, a 9/32-in. commercial fillet has 0.1476 lb. per ft., and with the operator depositing metal at the rate of 5.2 lb. per hr., you have only to divide 0.1476 by 5.2 to find the actual working time (arc time). In this case it is 0.0284 hr. per ft. The welder has 100 ft. of welding so you multiply 0.0284 by 100 and you get 2.84 hr. actual welding time or arc time as established by the actual time study.

Assuming that the time study man established an over-all efficiency of 50% for the welder, under normal average performance for the job, the welder would be actually welding 50% of the time. At 50% efficiency, the over-all time would be 5.68 hr. or double the arc time of 2.84. If the welder is paid $1.00 per hour for normal performance under the piece work system, this job would amount to $5.68.

Now let us take the same job and run it in production to see what happens with the actual time study when all the variables are excluded. In actual production you still have 100 ft. of 1/4-in. fillet of the weld down to a minimum. We will assume he actually holds it to an average 1/4-in. fillet but uses the electrode on the high heat range instead of on the low heat range as called for in the original procedure. This would give you 5.7 lb. deposited per hr. (see Table 1). On a 1/4-in. fillet he is depositing 0.1169 lb. per ft., or at the rate of 5.7 lb. per hr. The arc time or actual welding time for the job is then 0.0205 hr. per ft., or 2.05 hr. per 100 ft.

Assuming he is still welding at 50% efficiency, he will have twice the over-all time or 4.10 hr. Since you are paying him $5.68 for the job as established under the original piece-rate time study, his earnings are $5.68 divided by 4.10 or 1.38 per hr. The welder, running the same efficiency on production as he did before, increases his earnings from $1.00 an hour to $1.38 an hr. by cutting down the weld size 1/32 in. and by using the maximum heat range instead of the lower heat range on the electrode. NOTE: By just increasing his efficiency 5%, or by running 55% instead of 50% efficiency, he is able to earn $1.52 an hr.

By skimping 1/32-in. on the weld size specified, in other words by laying a 7/32-in. fillet instead of 1/4-in. fillet, he can increase his earnings to $1.81 an hr. with 50% efficiency basis. NOTE: By increasing his efficiency in this case by only 5% or to 55%, he can earn $1.97 an hr.

Here is another angle. Suppose the job is poorly fit-up, and he has the problem of putting in a little more weld than the original time study specified. In other words, instead of putting in a 9/32-in. fillet, he lays a 10/32-in. or 5/16-in. fillet, he will earn only 81¢ an hr. and if his day rate is 80 or 81¢ an hr., he will just make his day rate.

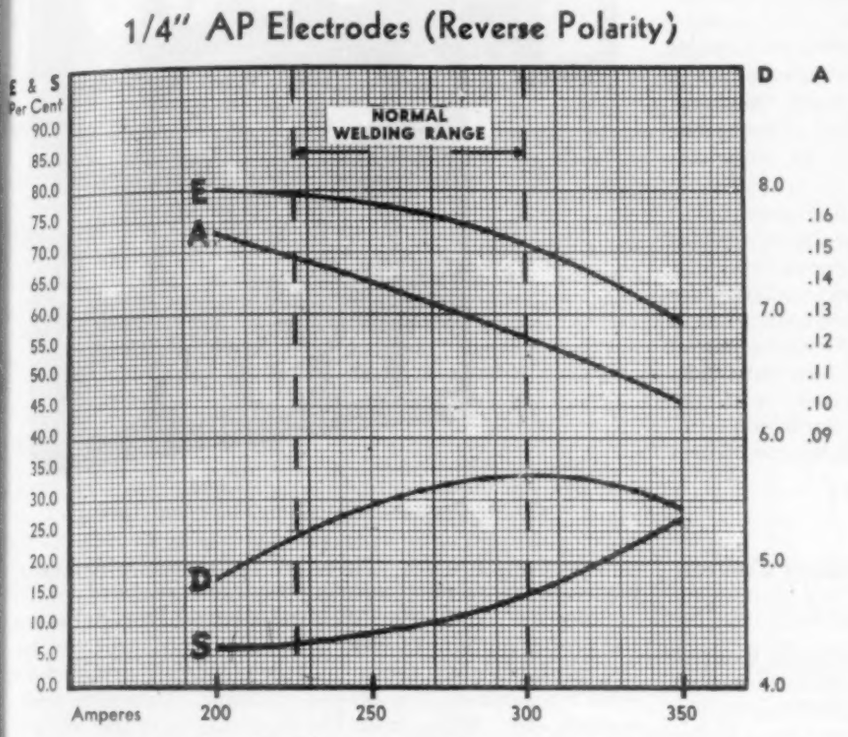
Every one of the above examples is perfectly legitimate. The job was studied from beginning to end—you had a 100% time study. You established your fillet size—you established your electrode size—you established the type of electrode and heat range. You established his efficiency, and the efficiency in these examples was held the same. In other words, without watching every move every minute, or without the protection of the Production Welding Control System, the welding operator can run his earnings all the way from $1.97 an hr. down to 81¢ an hr. by simply varying the fillet size or welding heat. Now, just picture what would happen under normal circumstances where a time study is not made in every case or where the welder has a chance to change the size of electrode or change the type of electrode and other little factors. The earnings will skyrocket.

You can readily see the big drawback in piece work. There is not enough spread between what you might consider too high an earning and breaking even, or not making out on the job. If there is trouble and the welder tries to do an honest job, he runs in the hole. That is, he will not make his day rate. If everything goes right, he will earn in excess of what might be considered a normal average earning. Another major weakness in the piece rate method is that there is no check whatever on the amount of welding that the time study called for or that is being paid for. In other words, during the time study you established an actual welding time. There is no assurance whatever that the actual amount of welding time is being spent on the job. The only check, and it is a most impossible one in production, is to measure the size of the welds, but even that is no guarantee that the same amount of welding hours were consumed as when the time study was made. The welder could have changed his electrode, he could have changed his heat range, or due to conditions, he could have done more or less welding than what you paid for. It works both ways. Under certain conditions, you penalize the welder by asking him to do more welding than your original time study called for, or under other conditions, you get less welding than the actual time study called for.

The cost of welding changes tremendously even with small variations in the size of the weld or with variations in the size of electrodes. For example, 100 ft. of 3/8-in. fillet using a 5/16-in. electrode at $1.00 an hr. labor and at 50% operating efficiency, costs $6.20—with a 1/4-in. electrode it is $9.22—with a 5/16-in. electrode, it is $12.36—with a 5/32-in. electrode it is $17.22. Roughly, by doubling your electrode size, the cost is reduced over 63%.

By doubling the fillet size with the same size electrode, your labor cost will be four times. In other words, if you have a 3/16-in. fillet made with a 3/16-in. electrode, it will

cost you a certain amount. Now, if you change that to a $^3/_8$-in. fillet (double the fillet size), your cost won't be twice as much, it will actually be four times as much. The reason for this is very simple. By increasing from a $^3/_{16}$-in. to a $^3/_8$-in. fillet, you are only doubling the fillet size but you are increasing the volume of metal in the fillet four times. Since the volume increases as the square and since welding cost is a matter of volume of metal, it requires four times as long or four times the number of lb., whichever way you want to express it. From a design standpoint, when you change from a $^3/_{16}$ in. to a $^3/_8$-in. fillet, you are doubling the strength but you are increasing your cost four times. That is why a little change in the size of a weld makes a big difference in your costs one way or the other.



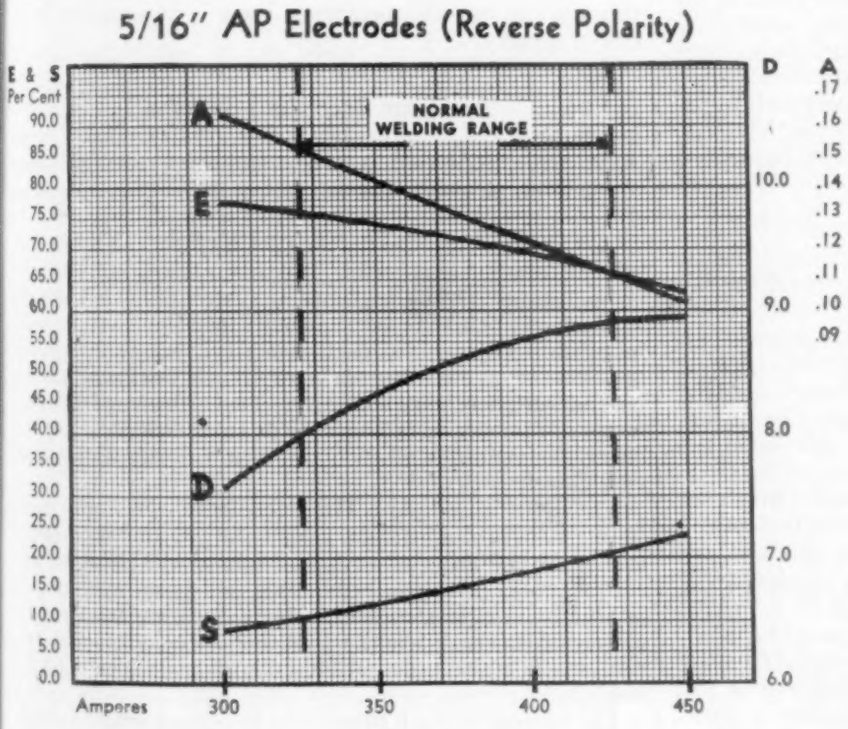


Fig. 1

Curve E Is the Deposit Efficiency or Actual Metal Deposited, Over the Total Weight of Electrode Melted Off. Does Not Include Stub Loss

Curve D Is the Deposition Rate or Actual Pounds of Metal Deposited Per Hour

Curve S Is the Spatter Loss or the Loss of Metal from the Electrode During Welding, Not Including the Coating Loss, in % of Electrode Weight, Melted Off

Curve A Is the Arc Time (in Fractional Minutes) Per 1 Inch of Rod Melted

Amperage Is the Actual Current at the Welding Machine Terminals

One thing you want to remember, a manufacturer must control costs in order to compete with other manufacturers. On a new product, a manufacturer must make the original cost estimate, he must determine that the product will cost so much labor, so much in material, so much in general manufacturing overhead, so much sales expense, so much profit, etc., so he can arrive at a competitive selling price. Let us assume that the product cost $1000 and the selling price is $1500. With labor or material variations on actual production, costs and selling prices are immediately affected. In many cases profit is entirely wiped out and selling prices are so high that the product cannot be sold competitively—and you know that a company cannot continue in business unless they make a reasonable profit. That is why, in manufacturing, your cost control is a tremendously important item. That is why a manufacturer of welded products should adopt a good sound cost control beyond what straight day work or piece work systems of compensation have to offer.

The Disadvantages of the Day-Rate Method of Compensation When Used by Itself

1. There is no check as to whether actual amount of welding (arc time) approximates the proper time called for by the original estimate.
2. There is no control over the welding heat being used.
3. It is easy to vary the size of welds.
4. Improper sizes and types of electrodes can be substituted.
5. There is no definite time limit for the job.
6. There is no control under group welding to indicate whether each individual workman is doing his share.
7. Costs frequently vary depending upon the amount of work available.
8. There is no production control because you have no definite elapsed time per job.

9. There is no check against the tendency to perform unnecessary excessive work.

NOTE: Items 1, 2, 3, 4 and 6 are the same as found under the piece-rate method of compensation. When the day-rate method is used as a functional part of the Production Welding Control System, all items but 5, 7 and 8 can be controlled. These can be controlled only under the base-rate-plus-premium method of compensation.

When operated independently or by itself, the base-rate-plus-premium method is basically the same as the piece-rate method, and entails many of the same advantages and disadvantages.

When the base-rate-plus-premium method of compensation is used as a functional part of the Production Welding Control System, all of the advantages of both the piece-rate and day-rate methods of compensation are incorporated. At the same time, all of the disadvantages of the base-rate-plus-premium method of compensation when used by itself are overcome. The base-rate-plus-premium method of compensation when used with the Production Welding Control System accomplished complete control of costs, procedures, production, and assures the highest quality of workmanship.

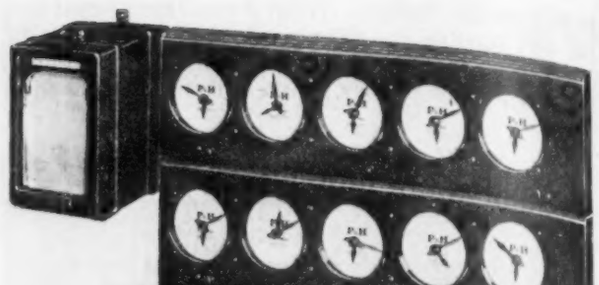


Fig. 2—Centralized Arc Time Recording System

Exactly What Does the Production Welding Control System Accomplish?

The basic purpose of the Production Welding Control System is to provide a definite method, all inclusive, of dealing with the basic problems of manufacturing by arc welding and to perform the various tasks involved at the lowest possible cost, regardless of existing conditions. In other words, it establishes the practical working time for each specific task, assures the workman of fair compensation according to his ability and energy and controls cost. The Production Welding Control System, therefore, is built around the four primary requisites: namely, the control of:

Costs . . . Procedures . . . Production . . . Quality

Under the System of Production Welding Control, arc time (the actual time that the welding operator is depositing metal) is the primary factor.

Practical experience indicates the desirability of establishing a definite arc time for each job. Meanwhile, the over-all time for each job remains within a definite, determinable range, depending, of course, upon the efficiency of each individual workman. But since the workman's premium is based on his efficiency, the over-all cost (base-rate-plus-premium) will remain fairly constant. This provides an accurate control of labor cost.

With the establishment of a definite arc time for each job, a definite welding procedure is set up incorporating the correct size of weld, how the welds are to be made, and the correct size and type of electrode to be used. This is accomplished by the engineering department or by the production department or a combination of the two, depending upon the set-up of the company in question. However, it does no good whatever to pre-establish these factors if you do not have a check in production to insure your actually getting what the original time study called for. A variation of the time study factors varies the arc time as established. This immediately indicates an excess or shortage of deposited weld metal or some other departure from the established procedure. This, then, provides an accurate procedure control.

Production control is almost entirely dependent upon control of cost (elapsed time) and procedure. With these two factors soundly established, work can be scheduled and properly routed. These are the factors which make it possible to exercise accurate production control.

Since the Production Welding Control System assures the proper amount of welding for each job, inspection for the most part becomes a matter of paying attention to weld appearance, the proper finishing of corners, ends, craters, etc. Thus, from the first stages of the job and through the various operations, there is an accurate control of quality.

Arc Time Recording Systems

We have used two arc time recording systems—the *Single Unit* and the *Centralized Arc Time Recording System*.

As the name implies, the Single Unit Arc Timer has the one big function of recording arc time. It is used in smaller operations where the complete system is not necessary or justified. This arc timer is built for mounting on wall or column adjacent to each welder. The accumulated arc time for one welding operator for one shift is obtained by individual readings of each clock. It is, of course, necessary for the time keeper to go from clock to clock to check the readings of each clock at the beginning and end of each work period.

The Centralized Arc Time Recording System, consisting of electrical timers, relays and graphic recorders, is a multiple-purpose service which, in addition to recording total arc time, provides a fool-proof system for production welding control. Every welding machine is connected through relays to a timer and the graphic recorders. Each recorder will handle up to 20 timers or 20 welders.

The purpose of each timer is to provide a visual record of actual arc time, in hours, tenths and hundredths of an hour. Each timer is connected in parallel with the recorder to provide simultaneously a graphic recording of arc time as a permanent record.

How the System Works

There are two distinctly different electrical timer hook-ups. One involves a current and a voltage relay while the other uses patented voltage relay controls.

Using the current and voltage relay method, the relays are connected to the terminals of the welding machine so that the current relay is in series with the welding circuit and the voltage relay is in parallel. The relays function to accommodate the three following conditions;

The arc timer will not register when the machine is idling;

The arc timer will register when and only when the machine is welding;

The arc timer will not register when there is a short circuit condition.

The disadvantage of this method is that the relays must be close to the welding machine. This means that the heavy welding current must be brought from the machine through the current relay.

When using patented voltage relay control, you have two voltage relays being used.

The arc timer will not register when the machine is idling.

The arc timer will register when and only when the machine is welding.

The arc timer will not register when there is a short circuit condition.

The big advantage in the two voltage relay method is that the relays are installed on the centralized control panel immediately adjacent to and entirely enclosed with the arc timers, out of the way and completely protected but convenient for the time and record keepers. Two small wires, similar to telephone wires, connect the relays to the welding machine.

How to Establish Arc Time

Under the Production Welding Control System, arc time is established in two ways: by actual time study; by theoretical process.

When a time study is normally made, without the use of the Production Control System, the time study man works with a stop watch. He records the time of actual welding, and all of the lost time increments in steps of two minutes here, a half minute there, or one minute here and one minute there, etc. When he is all through, he totals his welding time and totals his lost time. These, together, provide the over-all time for the job.

When you make a time study where the Production Welding Control System is in force, you have only to read the arc timer at the beginning and at the end of the job. In the meantime, you simply check to see that the welding operator is using the right electrode and putting in the right amount of welding, and record necessary lost time. The arc timer gives you the actual arc time while the number of hours worked on each job gives the total time. In this way, you do not have to have a time study man for each job as one man is able to study three or four jobs at the same time.

To establish arc time by theoretical method, one has but to remember that there is a direct relation between arc time and deposited metal. In other words, the deposited metal on a job can be considered arc time since the arc must be established a definite length of time in order to deposit a definite amount of metal. For example, the theoretical arc time for a job can be established from Table 1.

Take a $^1/_4$-in. fillet with a $^1/_4$-in. electrode of the reverse polarity, all-position type (Class E-6010). The arc hr. per ft. of weld is shown as 0.0205 minimum and 0.0227 maximum. If 100 ft. of $^1/_4$-in. fillet are to be deposited with this electrode, it would require approximately 2.05 hr. for a minimum arc time and 2.27 hr. maximum arc time. These figures show that the range between minimum and maximum arc time should be approximately 10%.

Knowing the value of arc time and how to obtain it for each job, let us take the next step of establishing over-all time.

In establishing the over-all time, you must take into consideration the compensation method used. If the day rate basis is being used, the company undoubtedly has past-performance records showing the length of time required for each job.

NOTE: Before putting in the Welding Production Control System, we found it very advantageous to give the employees and employee representatives complete information on the plan. In other words, it is well to let them know that if they perform the same under the Welding Production Control System as under the straight day-rate system, they would get the same amount of pay. If a company is under the piece-rate system and has piece rates established, it is well, from a public relations point of view, to inform your employees that, in putting in the system, you will pay your employees the same amount as they would earn under piece work if they turn the job out in the amount of time as established for the job.

Efficiency Rating

Knowing how the arc time and over-all or total elapsed time are established for each job, one simply divides the arc time by the total elapsed time to find the standard efficiency rating.

In our own plant, we developed standard efficiency ratings for various jobs passing through our plant by using, in the case of formerly established day rate, the average past performance and divided the arc time for the job by this past performance to obtain efficiency rating. Where former jobs had been established on piece work, we divided the established or theoretical arc time by the time previously required on the job and adjusted rates so that earnings would be approximately the same.

On jobs where day rates or piece rates were not previously established, or where the system was to be set up independent of past performance, standard efficiencies were established by determining the arc time and over-all time and then classifying the work into groups according to the ratio of handling time to welding time.

In our own plant we found that approximately five groups covered the majority of work. These standard efficiency groups turned out to be 39%, 35%, 30%, 25% and 20%. On an average these standards are exceeded by 20% by the operators, so that on an average the actual performance by the operator ranges from 59 to 40%.

By establishing these groups, you immediately establish a common ground for comparison, and you have the advantage of making a comparison between efficiencies instead of between prices or the costs per job. It is common knowledge that, in many plants, if you were to make a number of time studies on the same piece at different intervals, you would find that one time the costs would be $10, another time $15, and still another probably $8. If, when making a time study, you ask the question, "Is $10 too much, is $15 too much or too little, or is $8 more fitting," you will get any number of different answers. It is difficult to deal with these values. However, if you could say you were getting a 50% efficiency instead of it costing $10, or you were getting 25% efficiency instead of costing you $15, etc., you would have a direct comparison.

Another big advantage that should not be overlooked is that efficiency ratings provide a sound basis for comparing the abilities between welding operators as well as the

performance of one plant as against another plant under one company or between different companies.

Throughout our plant we adopted the base-rate-plus-premium method for paying our operators. In other words, the welding operator is paid a flat rate per hour and his premium represents the difference between his actual arc efficiency and the standard arc efficiency as established by the production department. The actual arc efficiency is determined by taking the actual arc time on the job and dividing it by the total elapsed time.

The difference between these two represents the amount by which the operator exceeds his standard performance. For example, let us take Job X. Assume that the actual arc time taken on the job was 5 hr. and total elapsed time required was 10 hr. The actual efficiency is 5 hr. divided by 10 hr., or 50%. The standard efficiency on the job was rated by the production department as being in the 35% group. Therefore, the standard efficiency was exceeded by 15%. This 15% in the case of our company is multiplied by an established factor of 1¢ for every % per hr. ten hours time at 15¢ equals $1.50 premium for the job. On this basis, both management and operator share in savings on the job and cost control is definitely established. Furthermore, it is accomplished in a manner whereby the operator is encouraged to increase his earnings (the company increases their savings).

The reason our company established this bonus plan was in order to simplify the calculations and to make it possible for the welders to understand so that they could quickly check their own earnings. In other words, all they have to see is how far they exceeded their standard efficiency and multiply by 1¢. Exceeding the efficiency automatically tells them what they make per hr. additional to their day rate.

There are two distinct advantages in this type of payment under this plan. The first is the premium added to the base rate, because in this way the older or higher skilled operators are assured of earning more than the beginners or poorer operators.

The other advantage is that, under the base-rate-plus-premium method of compensation, the system is what might be termed "Self Shocking." That is, an operator cannot run away with earnings although, even under bad conditions, he can still earn premium over his base rate.

Is the System 100% Perfect?

Every system, of course, has its advantages and disadvantages, and no system is ever 100% perfect. We do not claim our system is 100% perfect and that you will have no more troubles the minute it is established. However, we can say that there are a minimum of weaknesses and we want to point these out to you.

For example, under piece work the biggest disadvantage is that there is no procedure control. In other words, you have no measure of how much welding the operator actually gives you on production. And the tendency in piece work is for the operator to use too large an electrode and too high a heat, skimping on the weld because that is the way he makes the most amount of money under the incentive plan. This is true even though there is excellent supervision. Maybe you can keep costs in line and maybe you can't.

The tendency under our system is just the opposite. If you don't keep it under control the tendency is to use too small an electrode, too low a heat and to put in too big a weld. By paying him on the basis of the amount of welding he does, the operator, if he can get away with it, is going to try to put in as much welding as he can on the job because that is what he is being paid for. However, our experience has been that this weakness is by far preferable since you are able to produce quality welding. It is by far better to have a little too much welding on the job and have it put in with smaller electrodes and with lower heat than to have the job run with the wrong type of electrode, high heat, resulting in poor quality. Our control over the tendency to use smaller electrodes, etc., is by the established maximum arc time for each job. This gives the operator a 10% leeway between the minimum arc time and the maximum arc time. In other words, if the job has 4 hr. arc time, we expect the operator to stay between 4 and 4.4 hr. arc time, and this is checked on every job. When this is done, our system is as near 100% fool-proof as is possible . . . and in this manner control of procedure was developed to a fine point. Because the Production Welding Control System establishes control of cost and procedure—because the elapsed time on each job can be definitely determined, the production department can systematically control the jobs passing through production . . . you have complete production control.

Quality is also assured because each welding operator is given sufficient time to apply the proper amount of welding to each job. Inspection, for the most part, becomes a matter of checking weld appearance, the proper finishing of corners, edges, craters, etc. Since the welder is paid for the amount of welding he does, it is to his interests to do better welding.

The Production Control System has been applied in our shop for the past five years. It controls approximately 150 welders on two- and three-shift basis, and in the five years has been applied on over 25,000 different jobs ranging from pieces weighing only a few pounds with only several minutes of welding time, up to pieces weighing 40 tons and having several hundred hours of actual welding time. It is used on straight production welding, and welding of high carbon and alloy steels, and welds under rigid X-ray inspection.

Technical Control of Welding in Ship Construction*

By M. H. MacKusick†

WELDING of U. S. Maritime Cargo ships involves no complications of alloy steels or of air-hardening types of low-alloy carbon steels which require special welding procedure controls. The actual welding of the joints encountered is therefore relatively a simple matter of producing sound welds in mild carbon steel. The problems of a large commercial shipbuilding yard are therefore not of a highly technical nature but rather resolve themselves into two categories, namely:

1. Problems due to the large size of the welding personnel organization.
2. Problems due to the large size and complicated assembly of the structure being assembled by welding.

Commercial shipbuilding back in the early part of 1940 was very limited in scope. Fortunately just as our leaders in Washington foresaw the need for a vast aircraft building program, they also foresaw the need for a vast shipbuilding program. Therefore, in the early part of 1941, several Maritime shipbuilding emergency yards were started. The original planning when these yards were started contemplated that 10,000-ton cargo ships would be built at a rate to provide one launching from each shipway every 4 mo. By exploiting welding methods to the limit and by using subassembly methods and through a continual training program these same yards have exceeded the originally contemplated construction rates by some 800%. One yard has constructed 2 ships per way per month for a sustained period of time during the latter part of the Liberty Ship construction program.

Such a tremendous output of welded construction has involved many problems of adequate quality control, some of which will be outlined in this paper.

First, I would like to outline the speed of growth of the welding personnel at Calship. Figure 1 shows the number of welders working, and the feet of welding done by months, during the period of growth of the organization.

Training of welders has been an ever-present necessity. During the early part of the shipbuilding expansion program, training of welders was done for the most part by our War Training Program under the direction of the National Government Agency which enlisted the aid of the state school systems. Also numerous private welding schools were in existence. It soon became apparent that additional training facilities would be required and many of our large shipbuilders started their own training schools to supplement the national program. The free training program of the Government soon eliminated the private training schools and today on the West Coast at least, the free Government-operated training schools are having

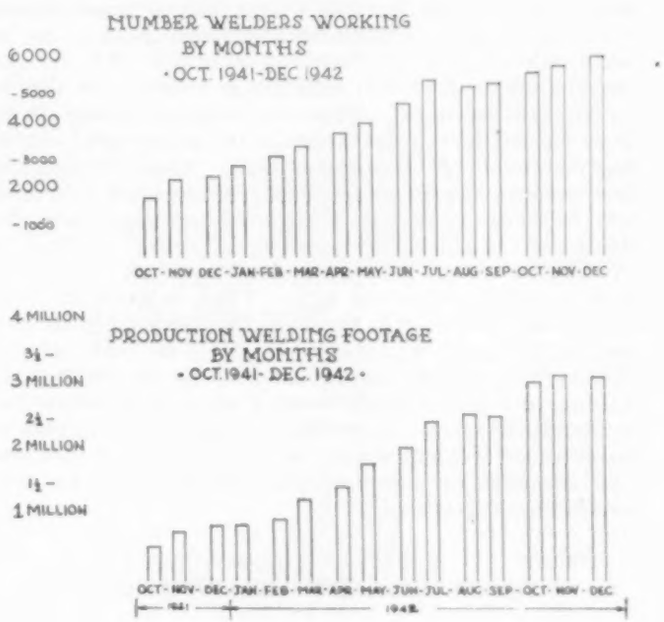

NUMBER WELDERS WORKING
BY MONTHS
• OCT. 1941-DEC 1942
6000
5000
4000
3000
2000
1000
OCT · NOV · DEC · JAN · FEB · MAR · APR · MAY · JUN · JUL · AUG · SEP · OCT · NOV · DEC
4 MILLION
3½ -
3 MILLION
2½ -
2 MILLION
1½ -
1 MILLION
PRODUCTION WELDING FOOTAGE
BY MONTHS
• OCT. 1941 - DEC. 1942 •
OCT · NOV · DEC · JAN · FEB · MAR · APR · MAY · JUN · JUL · AUG · SEP · OCT · NOV · DEC
1941
1942

Fig. 1—Shows the Number of Welders Working, and the Feet of Welding Done by Months, During the Period of Growth of the Organization

difficulty maintaining adequate enrollment as the commercial schools such as the one at Calship are training welders at helpers' rates and hence attract what man power is left from the state-operated schools. In order to use the existing training facilities in the national program, many of the shipbuilders are assigning paid training programs to the schools in their district; such a scheme has worked very successfully at Calship. To give you an insite into the scope of the training program it is of interest to note that at Calship our training program for welders has at times had an enrollment of over 800 welder trainees and seldom has gone below 450 people in training. During 1943, the turnover of welders at Calship required from 600 to 700 welder replacements per month out of a total enrollment of approximately 7500 welders in the production departments.

Incentive Systems of Pay

It was early recognized that to pay all welders the same hourly rate eliminated the value inherent in incentive system of pay especially when so many newly trained inexperienced welders were involved. We therefore worked out an agreement with Labor and the USMC to pay our trainee welders according to the three welding tests for flat, vertical and overhead welding. This graduation of pay rates has been only partially successful as there is still a wide variation in the value of the experienced

* Presented at the Twenty-Fifth Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 16 to 19, 1944.
† Assistant Shipyard Superintendent and Welding Engineer, California Shipbuilding Corp.

3-position welder as compared to the newly trained 3-position welder yet all 3-position welders are paid the same rate. A provision for rewarding the good experienced welder who can and does produce more sound welding than the newly trained welder should be established. Such a system could be limited to say 20% of the entire welding personnel and also stipulate that the welder receiving a premium rate of say 10¢ per hour, must have a minimum of 6 mo. service to qualify. This would help reduce the turnover of welders and in addition would provide an incentive system of advancement.

Incentive systems using piece-rate methods for payment of wages are only as good as the original time studies made to establish the piece rates. Also many complications arise such as time involved in accurately establishing the quantity of acceptable work done by each individual welder and an equitable rate of pay commensurate with the difficulties encountered due to location of the work. Piece-rate welders in some yards have earned money in excess of the salary paid to the superintendent of the department. There is also the ever-present hazard of piece-rate welders using fraudulent methods to increase their welding footage and also the hazard of the welders and weld counters or checkers working in collusion to fraudulently pad the work records to obtain unearned pay. There is a lot of room left for improvement in the wage incentive methods now used in shipbuilding pay systems. It is my personal conviction that a decided improvement in the efficiency of our welding man power would result if steps were taken immediately to solve this problem. Moreover, the rate of turnover of welders would be reduced and hence the load imposed on our training schools would be correspondingly decreased.

Qualification of Welding Operators

Manual welding depends upon the skill of each individual operator. Qualification tests for operators have been established by the regulatory agencies and provide a reasonable index of the ability of a welder to satisfactorily perform production welding. The qualification tests do not, however, guarantee that operators will continue to weld in production with the same degree of effort as was used when making the tests. The problem then becomes one of supervisory control. Unfortunately the prescribed procedures for qualifying operators have not been followed consistently in all shipyards. I believe that it can definitely be proved that the average quality of welding in any large shipbuilding yard will vary directly with the degree of effort applied in the qualification program established. It is certain that a welder who is unable to make a satisfactory qualifying test will never produce good production welds. In this sense then, our qualifying program becomes merely a "screening-out" process but does materially aid the production supervisory staff to obtain a better control over welding quality. The weld testing department at Calship is shown in Figs. 2 and 3. Test results are obtained from all of the previous day's test plates by 10 A.M. each morning so that no delay in advancing the welders to the next pay bracket occurs. Test coupons that fail in the physical test are placed on a convenient bench where the welder and his instructor can examine the unsatisfactory weld and profit by the information gained. Where the testing of welders involves an increase in pay rate it has been found very necessary to positively identify each welder being tested to eliminate any attempts at fraudulent methods in obtaining qualifications. Identification of welders is a simple matter in most of our shipyards as all employees are required to carry an identity badge with photograph, fingerprint and signature.

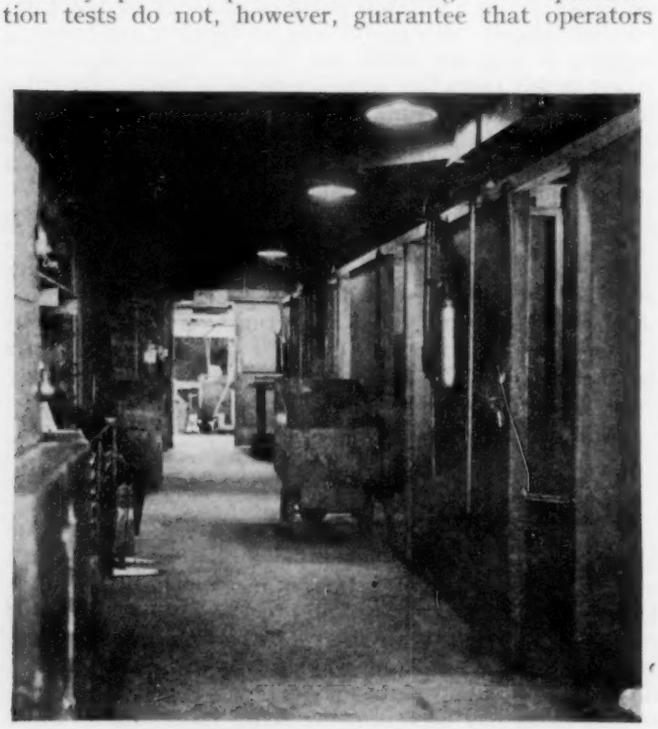


Fig. 2—Weld Testing Department at Calship

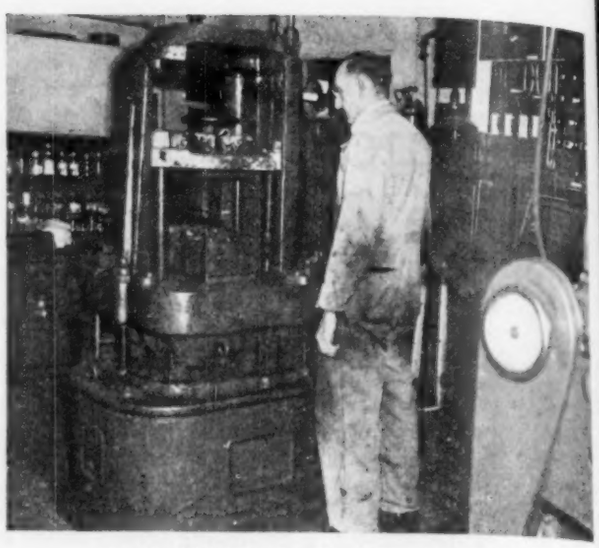


Fig. 3—Weld Testing Department at Calship

Organization for Shipyard Welding Production

There are two general organization plans for welding in use in our shipyards. From a welding point of view the system of organization where all welding personnel is organized within a single welding department is most satisfactory.

From an over-all production point of view many yards prefer to organize by departments, for example, the plate and structural shop, subassembly, shipways and outfitting departments are organized complete within each department and each department has a welding unit of its own. There are advantages in both plans of organization; the latter system of organization by departments has been more widely used to obtain maximum speed in production since each department is wholly responsible

United States Merchant Ship Production (1936-44)

Year	Number Vessels	Deadweight Tons
1936	9	107,938
1937	18	194,788
1938	25	289,765
1939	28	341,219
1940	55	641,056
1941	99	1,137,163
1942	746	8,089,732
1943	1896	19,238,626
1944*	1640	16,463,804

* Based on first quarter 1944.

Fig. 4—Shows the Tonnage of Shipping in "Deadweight Tonnage" and Also the Number of Vessels Constructed for the Period 1936 to 1st Quarter, 1944

for maintaining its production schedule. The integrated welding organization in a single department provides more flexibility and tends to reduce the over-all man-hour cost of welding since production peaks can be met by shifting of welding personnel. Either of the two methods of organizing welding supervision will give good results and the degree of success will depend upon securing the services of competent supervisors and the ability of management to cultivate teamwork and a cooperative spirit between departments.

Automatic Welding

Most shipyards organize a separate welding department to handle their automatic welding. The use of submerged-arc automatic welding is principally confined to subassembly operations, although some yards do certain types of joints on the shipways. At Calship, the use of automatic welding is confined to the plate shop and subassembly and all shipway welding is done manually. The use of E6030 type manual electrodes plus the fact that less movement of equipment is involved has prompted our decision to eliminate the use of automatic welding on the ways. It was found that delays in scheduling an automatic machine for a certain weld plus the cost of handling the equipment to and from each joint exceeded the cost of welding the same joint by hand. Also many joints could not be completely welded by machine due to clearance for the machine at hatch coamings and side shell ends of deck butts so that a certain amount of chipping and manual welding was required on a number of the welds in any case. It is our conclusion, therefore, that shipyards working to a fast launching schedule will find that automatic welding should be entirely concentrated on subassembly work for economical and fast production results.

Planning for Subassembly

The remarkable achievement of construction speed in shipbuilding is best illustrated by the record of merchant ships produced during the last 8 yr. Figure 4 shows a table of the tonnage of shipping in "deadweight tonnage" and also the number of vessels constructed for the period 1936 to firstquarter, 1944. This remarkable production record has been achieved by using subassembly methods with specialized crews of workers doing the same series of operations on each ship. Systematic study of subassembly methods is one of the major factors in fast ship construction. Most subassembly work is assembled in the inverted position to provide down-hand welding which has obvious advantages over vertical and overhead welding so far as speed, quality and cost are concerned. However, certain assemblies are made in the upright position as the cost of handling and turning over certain types of assembly may outweigh the advantages of inverted construction. An example of the latter case is the stern-casting assembly shown in Fig. 5. Even though this unit is assembled in the upright position the cost of doing the work with specialized crews in fixed location is much less than assembling the unit on keel blocks on the shipway.

Figure 5 (*a*) shows a fore-peak assembly with shell plating not yet in place on the starboard side. Automatic welding is used throughout the subassembly area for flat position butts and seams of plating. Side shell sections with curvature are positioned in steel cradles which conform to the shape of the hull. It has been found by careful study that Union-melt welding can be done on sloping plating up to certain limiting degrees of slope. The limits established for maximum slope of plating in Unionmelt welding at Calship are as follows:

1. Maximum degree of uphill slope—8°.
2. Maximum degree of side hill slope perpendicular to direction of weld—15°.
3. Maximum combination of uphill slope plus side hill slope—20°.

The Unionmelt machine must be operated in the climbing direction whenever slope is encountered.

Unionmelt welding of thin plates has always been a problem in shipyards as the puddle of molten metal is much more likely to burn through on light plating. Figure 6 shows a method for assembling and Unionmelt welding light plates from $^3/_{16}$ to $^3/_8$ in. thickness. This unit consists of two magnetic chucks on each side of a 2-in. square copper chill bar. Conveyor tables with rollers are used to bring the plating up to the magnetic hold-down jig and a second set of roller tables is used to pass the welded plates to a turnover rig where a second magnetic jig is used to hold the plates, for welding the

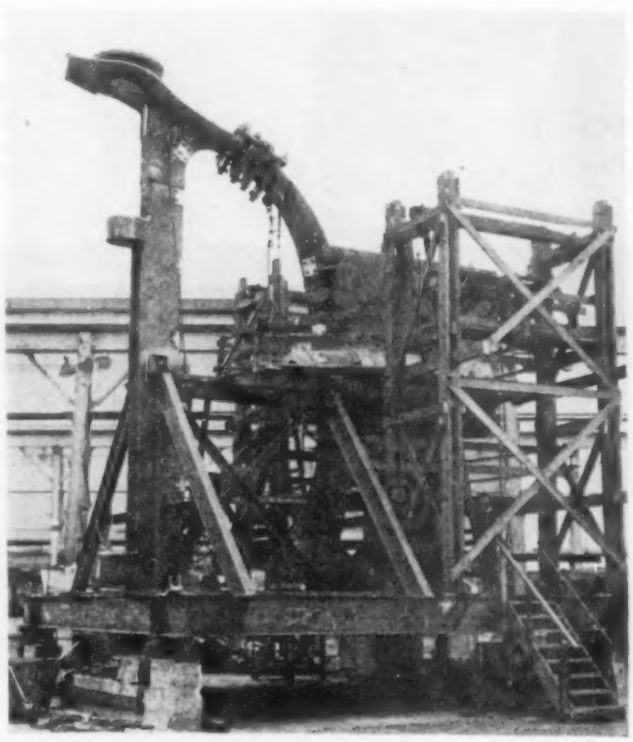


Fig. 5—Stern-Casting Assembly

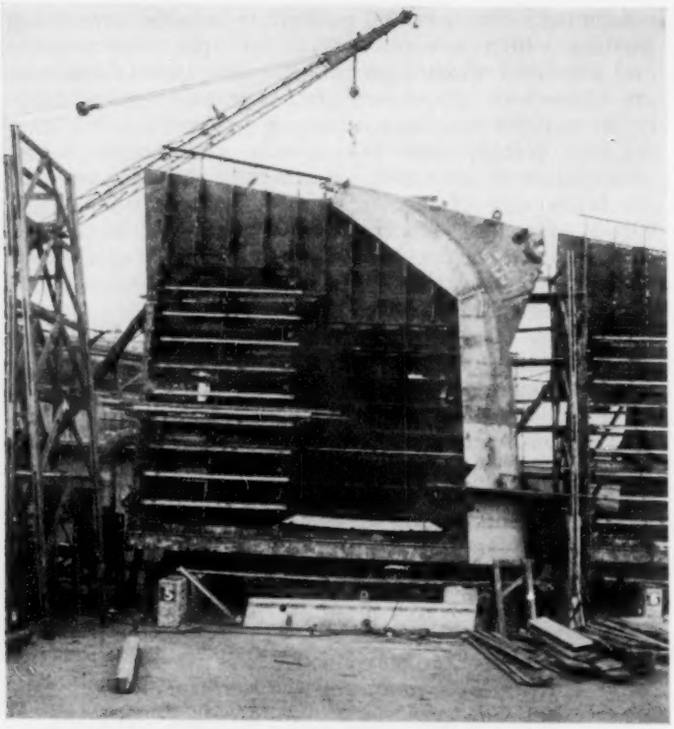


Fig. 5 (*a*)—Fore-Peak Assembly with Shell Plating Not Yet in Place on the Starboard Side

second pass. The magnetic jig unit is mounted on air jacks which drop the unit away from the under side of the plating when the welded plates are rolled to or from the welding position. It was necessary to investigate the problem of magnetic interference with the electric arc before this welding unit was built. It was found that by keeping the magnetic poles of the hold-down units properly polarized and spaced 1 in. away from the line of welding no interference was encountered. When plates of less than $^3/_{16}$-in. thickness are welded it is necessary to place a magnetic plate on top of each side of the work to eliminate stray magnetic field. A similar scheme could be used for holding down nonmagnetic steels or nonferrous sheets.

Much of the welding on subassembly involves the attachment of stiffeners to plating. The usual practice for welding such stiffeners is to apply 3-in. weld increments in a staggered spaced arrangement with the space between weld increments determined from tables or curves of accepted strength requirements. At Calship, fillet welds are made in the down-hand position with E6020 type electrodes using the "deep fillet" or penetrating type of fillet weld. It was found, however, that deep penetrating fillet welds could be made in short 3-in. increments but the large number of deep craters involved required excessive repair work. A substitute spacing of weld attachment of intermittent fillets was therefore investigated using a 12-in. increment on a 26-in. staggered spacing. Two test bulkheads were built, one of which was welded with 3-in. staggered increments and the second was welded with the alternate 12-in. staggered increments of equivalent average strength. The two bulkheads were assembled to form a pressure-tight box and tested under pressure. Figure 7 shows the test assembly used with the stiffeners on the outside of the bulkhead assembly. The test was made in two parts, first, with the stiffeners on the outside of the assembly and second, with the stiffeners on the inside of the assembly. In both tests it was determined that either arrangement of weld spacing was adequate to withstand

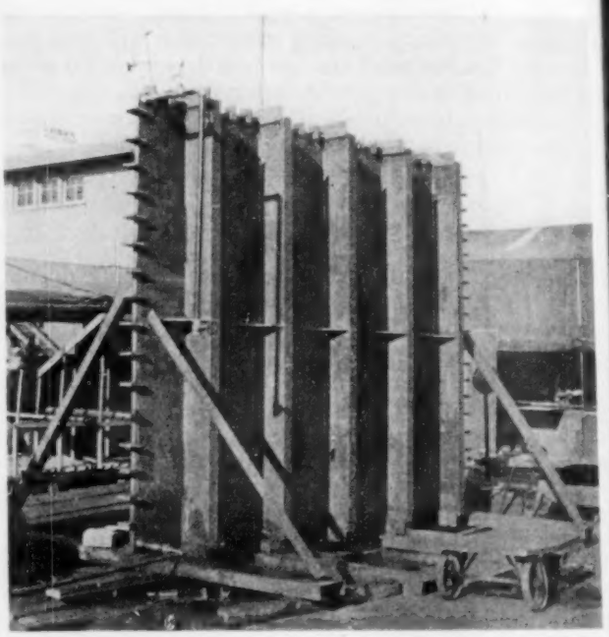


Fig. 7—Test Assembly Used with the Stiffeners on the Outside of the Bulkhead Assembly

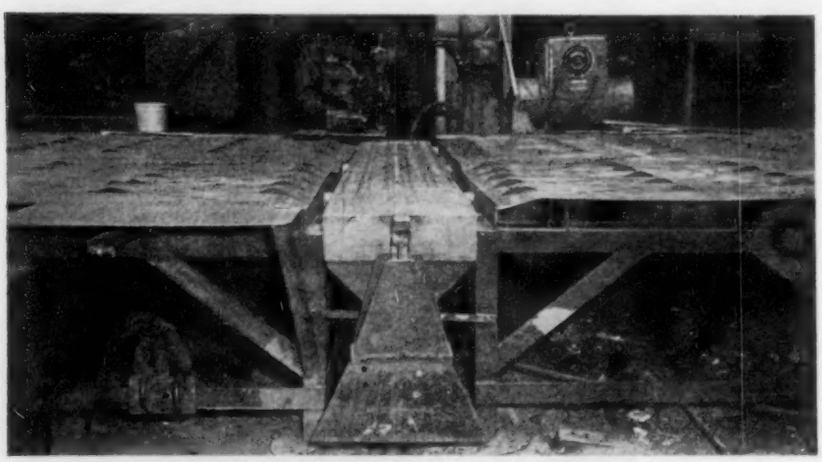


Fig. 6—Method for Assembling and Union-Melt Welding Light Plates from $^3/_{16}$-In. to $^3/_8$-In. Thickness

pressures in excess of design requirements and the two types of weld spacing appeared to stand up equally well during the tests. Permission to substitute "long increment" welding in place of 3-in. increment welding was obtained from the American Bureau of Shipping so that the faster welding procedure could be used for practically all subassembly fillet welding.

It may be of interest to discuss briefly the "deep fillet" method of welding. It has been proved in several reliable, testing laboratories that the depth of penetration obtained in flat positioned fillet welding increases with speed of arc travel up to a certain limit. Figure 8 shows two fillet welds, the one on the left is a "deep fillet" weld made at an arc travel speed of 10 in. per minute while the one on the right was made at an arc

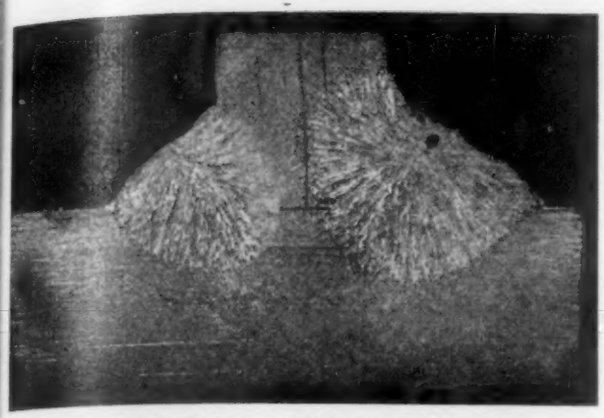


Fig. 8—Two Fillet Welds; the One on the Left Is a "Deep Fillet" Weld Made at an Arc Travel Speed of 10 In. per Min. While the One on the Right Was Made at an Arc Travel Speed Exactly One-Half as Fast, or 5 In. per Min.

travel speed exactly one-half as fast or 5 in. per minute. Note that the throat depths of the two fillet welds are practically identical. Note also that in the slow speed weld the arc energy has been more widely spread out in a side direction but has not added to the strength of the weld. Analysis of the mechanism of arc stream penetration provides a logical explanation of this phenomenon. A slow arc speed permits a substantial puddle of liquid metal to form beneath the arc stream and hence the arc stream force is transmitted by fluid pressure in the puddle equally in all directions. You will recall from your physics that hydrostatic pressure is equal in all directions, so in this case a considerable amount of arc stream energy is converted from a direct penetrating direction to a hydrostatic flow in all directions, hence the side spreading action of the slow speed weld. It follows that penetration will increase if the depth of the molten puddle is kept at a minimum directly below the arc stream. This can be done in two ways, first, by increasing the speed of travel and second, by running the arc slightly uphill in which case gravity pulls the puddle away from the arc stream. In order to obtain consistent results with a penetration procedure all variables must be controlled. Arc voltage is maintained constant by using a light dragging technique with the electrode coating in light contact with both sides of the fillet assembly at all times. This dragging technique also tends to minimize undercutting as the arc stream is shielded by the coating to a certain extent. Arc current is established in one of several ways, first by ammeters but it is important to note that meters on the average portable welder are not usually reliable; however, a clip-on type

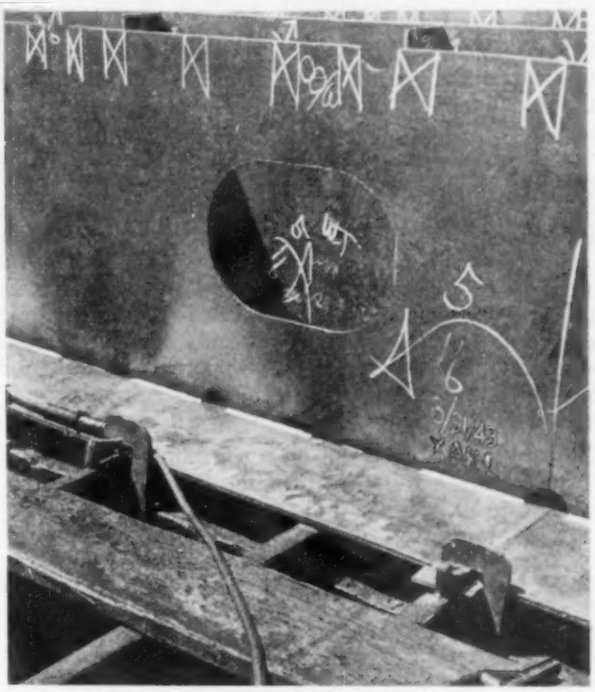


Fig. 10—Method of Weld Layout or Weld Marking Used on Liberty Ship Double-bottoms

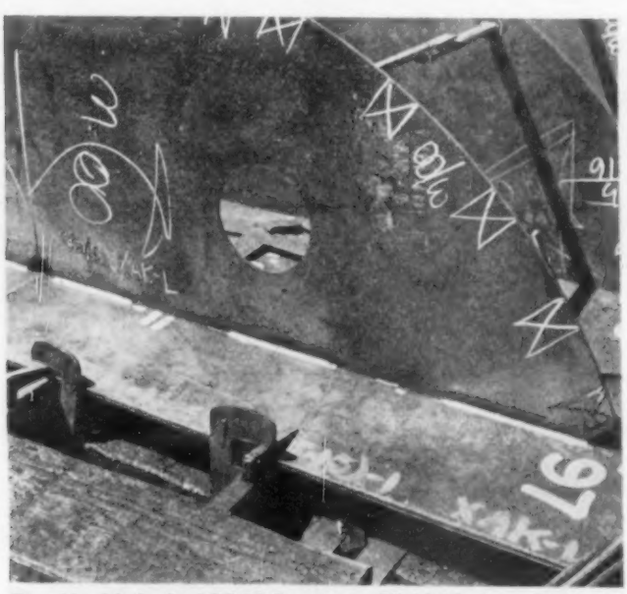


Fig. 11—Method of Weld Layout or Weld Marking Used on Liberty Ship Double-bottoms

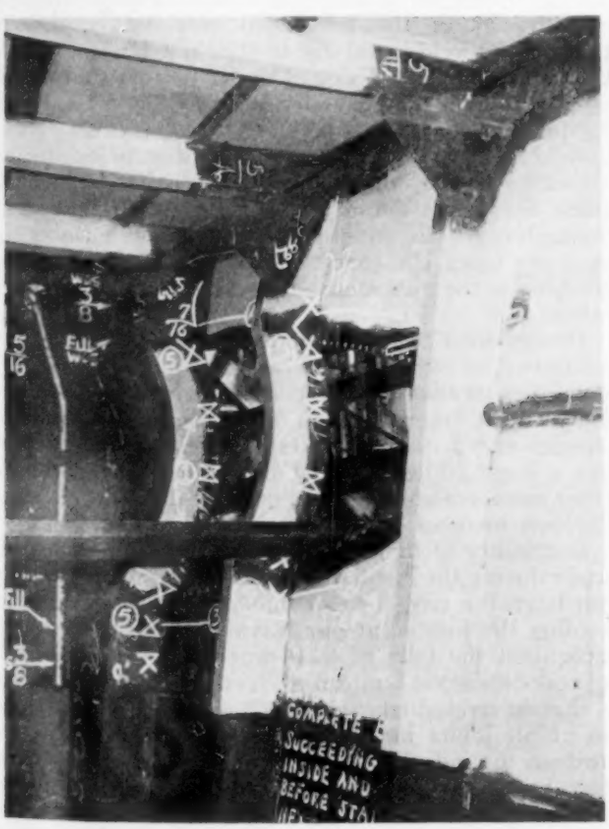


Fig. 9—The "Weld Layout" Crew Is Charged with Marking All Steel for Size and Location of All Welding Which Is Painted on the Work

of ammeter can be of valuable use. A good standard method of determining welding current is to time the quantity of electrode consumed for a given period of time; i.e., determine the "burn-off" rate.

The use of penetrating fillet welds introduces complications in production. Cooling rates are high because of the high arc speed hence the weld is more susceptible to cracking. Temporary tack welds should be skipped until a solid block of weld has been made on each side of the tack in order to eliminate absorbing the fitting stresses in the fillet weld. Standard practice of allowing 0.020 to 0.030 in. clearance between members during fitting is also very important if deep fillet welds are to be used. Another complication involves the high ratio of dilution of filler metal with base metal which occurs with the deep penetration type of fillet weld. If the base metal is high in hardenability constituents, carbon or manganese in mild carbon steels the cracking tendency will be increased. Sulphur tends to create a hot-short condition and high sulphur content of base metal will cause cracks. In spite of production difficulties excellent results can be obtained by using a deep fillet procedure if reasonable fitting standards are maintained and the welding is made to conform to the prescribed technique.

Welding Sequence is very important in assembling large welded structures, especially in shipbuilding; its purposes are:

1. To determine the best chronological order of making welds to provide minimum restraint of shrinkage.
2. To minimize distortion.
3. To prescribe correct order of welding where structural members intersect seams and butts in plating and to prescribe correct order of welding where seams and butts intersect.

It is impossible to prescribe a sequence which can be accurately followed for every inch of welding in a ship which contains 250,000 or more lineal feet of welding. A plan for welding the main structural members in sequence should be used in combination with a set of prescribed rules for welding at intersections. At intersections, it is the practice at Calship, to paint the proper sequence on the steel and this is done by a special crew

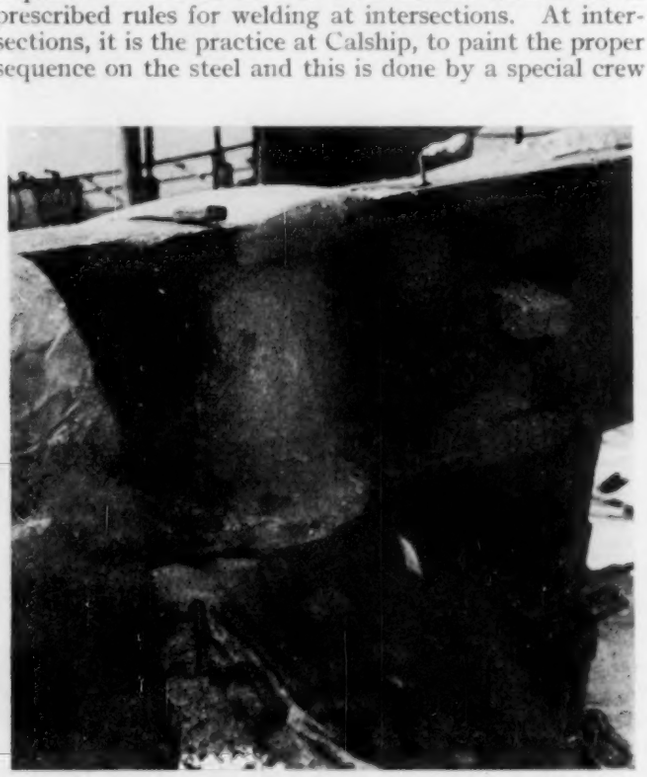


Fig. 12—Thermit Weld in the Process of Being Waxed

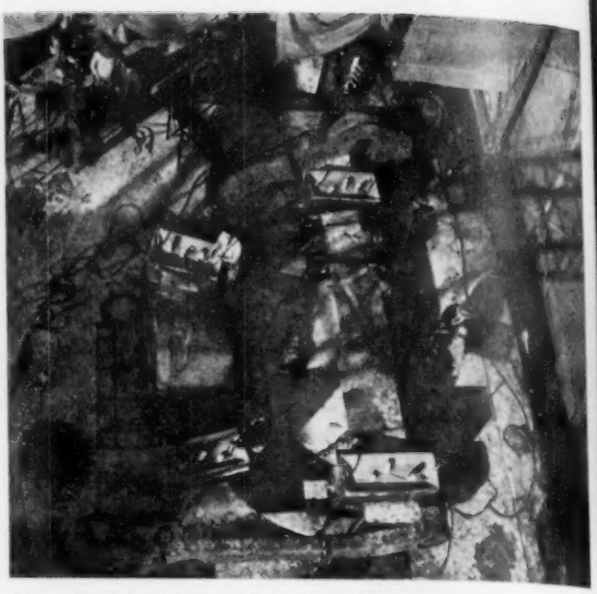


Fig. 13—Stern-Casting with Four Thermit Weld Moldboxes in Place Ready for Preheating

of trained men known as the "Weld Layout" crew. The same crew is also charged with marking all steel for size and location of all welding which is painted on the work. See Fig. 9.

Figures 10 and 11 show method of weld layout or weld marking used on Liberty Ship double-bottoms.

Correct sequence should always maintain symmetry about a center line and this applies to subassembled sections as well as to the final hull assembly.

The one item in shipyard welding sequence which requires the greatest attention is the tendency for welders to run a fillet or butt weld past an unwelded intersection in an adjoining member. This practice will often result in the first weld cracking transversely through the weld metal due to the "notch effect." Such cracks are difficult to detect under normal shipyard inspection and if undetected will always be a focal point for propagation during service. "Notch-effect" cracks in weld metal are caused by concentration of longitudinal shrinkage at the notch; it is obvious that longitudinal stress lines must detour at the notch and superimpose themselves on the stress in the continuous member and in many cases the concentration is sufficient to cause cracking as the weld metal cools through the blue temper range.

Distortion of a ship's structure during welding must be minimized by control of welding sequence and procedure. It is obvious that all members of a ship's structure are designed to transmit their share of the service load stresses and a distorted deck or shell will behave just like a loose fiddle string, it cannot play its part until other members are stretched out to take up the slack in the loose member.

Continuity of hull design has been a subject of wide study during the last 3 yr. A ship designed for riveting can have the rivet holes eliminated and assembled by welding the joints but our Naval Architects have fully recognized the folly of such practice. The one fundamental difference between a riveted and a welded ship is that in riveted construction, load stresses are broken up at all joints into increments of stress which pass through the individual rivets. True that certain rivets may be overloaded at times and become loosened or even snap out but still the load stresses will flow into the remaining rivets. Not so in a welded structure, stresses flow in continuous parallel paths and when poor continuity of structure exists stresses concentrate at the

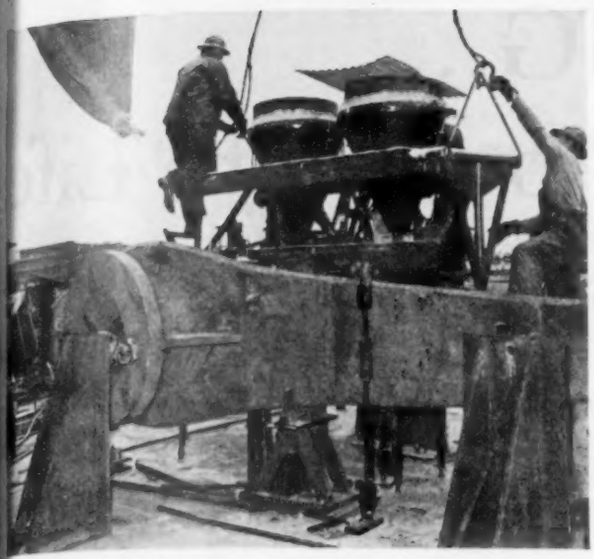


Fig. 14—Placing the Thermit Reaction Crucibles Over One of the Welds

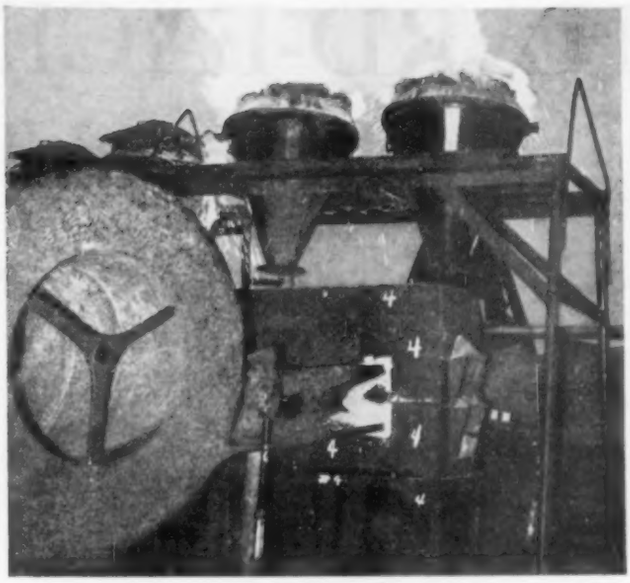


Fig. 15—Thermit Reaction Taking Place

abrupt change of structure and instead of popping a rivet, a weld starts tearing loose, and welds once started may tear the main plating of the ship. A welded ship which has good structural continuity is a stronger ship than one in which the numbers are punched full of rivet holes. Service conditions have shown that special attention in design must be given to hatch corners and to the corners of the mid-ship deckhouse. The ship hull is in effect a large box girder and at hatch corners the girder contains discontinuities which must be well rounded out to eliminate excessive concentration of stress. Also the mid-ship deckhouse forms a secondary box girder which stiffens up the structure at the central portion of the hull where stresses are at a maximum. A flexible bar will bend uniformly under stress but stiffen up the center part of the bar and stress concentrations will exist at the change in section. Consideration has been given to use of a doubler plate on the main deck to which the deckhouse bulkheads could be welded to form a water-tight connection which would provide flexibility and prevent the deckhouse itself from causing excessive stress flexure at the corners of the house in the main plating.

Thermit Welding

The large stern casting for our Victory Ships is cast in four pieces and is assembled in the Yard by Thermit welding. Due to the production schedule required at Calship, it was necessary to attempt a Thermit welding procedure which is somewhat of an innovation. All four of the Thermit welds involved in a stern frame are made up at one time and the welds are poured consecutively over a period of about 2 hr. The usual practice is to make two welds at a time but the long preheating and cooling period involved prohibited making two series of welds as it was necessary to finish a stern frame every two days. The pouring of four Thermit welds in a single assembly has worked out entirely satisfactorily. No disturbance of the mold boxes has been experienced, at least not to the point of causing the loss of a weld by runout of the molten Thermit. Figure 12 shows a Thermit weld in the process of being waxed. Figure 13 shows the stern casting with four Thermit weld mold boxes in place ready for preheating. Figure 14 is a view showing the placing of the Thermit reaction crucibles over one of the welds and Fig. 15 shows the Thermit reaction taking place.

In closing, it should be noted that in spite of the inexperience in design and fabrication of welded ships which existed at the start of the emergency shipbuilding program only 6 out of over 2000 Liberty Ships have been lost because of structural failure and that loading conditions have not in all cases been in accordance with best loading practice. Also, in heavy weather the ship's master must maintain his speed and direction as specified by convoy orders rather than handle his ship at his own discretion as is the case in peacetime operation.

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Controls Required for Safe and Economical Construction of Welded Ships*

By Donald G. Maxson†

PART I—INTRODUCTION

TODAY is the day of the "secret weapon," one in which the tremendous endeavors of research and industry are being so largely devoted to obtain new weapons and tools of destruction to help win the war. It is "no secret," however, that the outstanding weapon or tool of modern times which has contributed more than any other single tool or weapon in the tremendous industrial output required to win the war has been "welding." This has been true in industry in general, but more particularly so in meeting our tremendous construction program in the shipbuilding industry. Without welding and its facilities in enabling us to so quickly train the hundreds of thousands of "richmen, poormen, beggermen, thieves, doctors, lawyers, merchants and chiefs," into craftsmen capable of uniting the component parts of ships into a completed whole in the record-breaking time established during our war effort, it would have been impossible to turn out our "Seven Seas Navy," our Merchant Fleet of cargo, transport, tanker and other categories, our "new secret weapon" of landing craft and the rest of this world's unprecedented shipbuilding program.

In the application of this great tool of welding, in the early and rapid expanding war program, we were quickly reminded of nature's ever prevalent law that the abuse of any good thing soon leads to retribution, whether it be a tool of industry or those gifts of nature which sustain life itself. This fact was thrown right into the laps of the shipbuilding industry, and more particularly those of us who were more closely associated with the welding phase by the series of failures which began to occur in welded ships in the latter part of 1942 and which was most strongly brought to our attention by the failure of the tanker *Schenectady*. These failures rapidly developed into an epidemic and it was soon apparent that we had a very sick patient on our hands.

The investigations and surveys which quickly resulted from these failures, however, brought forth one hopeful premise in that it was found that welding, as the all-important tool in the uniting of the many component parts of a ship into a safe and sound vessel, was basically sound and efficient; it having been found with rare exceptions that the welds themselves even with the comparatively inexperienced welding personnel available were satisfactory and equal in strength to the adjoining parent metal.

On the other hand it was very evident that prompt and efficient steps must be taken to control and hold in check the "subtle ailments" which directly or indirectly were causing these failures.

It is in the field of our diagnosis of these "subtle ailments" and in the prescriptions in the form of proper controls which have been set up and operated at Marinship and which it has been found necessary to extend from the drawing board to the completed ship that the writer has chosen as subject of this article. The conditions have been such as to make this approach somewhat unique, and further, these controls have come a good part of the way in assuring the safe and economical building of all welded vessels.

PART II—THE CASE HISTORY

The Anxious Parents

The new year of 1943 found Marinship changing over from the construction of Liberty ships to the raising of a family of all-welded tankers of similar construction to the stricken *Schenectady*.

The Management, like the good parents of any large family, was well aware of the necessity of guarding against the epidemic of "subtle ailments," referred to in the Introduction above, and by nature one of the first steps was to look for medical advice and assistance.

Calling in the Doctor

At this time the writer was employed as Welding Adviser and Consultant for the three associated "Bechtel" Shipyards: Calship at Terminal Island, Calif.; EvansShip at Evansville, Ind., and Marinship at Sausalito, Calif.; devoting approximately an equal amount of time to each in connection with various and sundry welding problems. Through the efforts of R. L. Hamilton, Production Manager, arrangements were made for my release from the other two yards except on a call basis so that I could devote the greater portion of my time to the development of welding sequences and procedures for the new tanker program.

The Family Physician

The writer's approach in the endeavor to curb the "subtle ailments" referred to heretofore has been along the lines of the old-time family physician of living right with the patient, constantly taking his pulse and temperature and prescribing the necessary diets in the form of proper controls and the like, rather than the "Park Avenue Specialist" looking for highly technical or other cure-all drugs.

The Preliminary Diagnosis

Knowledge of the failures referred to in the Introduction, first came to the writer in the latter part of December 1942 while on a tour of duty at the Yard in Evansville, Ind., in the form of an urgent call to be present on the subsequent afternoon to meet J. Lyle Wilson, Assistant Chief Surveyor of the American Bureau of Shipping at the Calship Yard at Terminal Island; in connection with the survey he was making of a number of failures which had developed under service conditions. I immediately got under way in the midst of a mid-western blizzard and after a rough and rugged plane trip arrived at the conference which was cut rather short due to Mr. Wilson's leaving for Portland, Ore., in connection with the failure of the S.S. *Schenectady* which had occurred in the interim.

During the subsequent weeks I was privileged to spend a considerable amount of time with Mr. Wilson, as well as the group of experts of the welding fraternity from the Maritime Commission, Bureau of Ships from the Navy Department, the shipbuilding industry and the scientific field who aided Mr. Wilson in investigating and reporting on these failures.

The results of these investigations made by Mr. Wilson and his associates, as well as the writer's own observation, brought forth the following preliminary diagnosis:

1. Cause of Failures.—It was definitely established that the failures which were occurring were caused by an excessive accumulation of residual stresses in the steel structure during the construction period, which when additional service stresses were superimposed from various causes, produced fractures which were apparently of an explosive nature in that the fractured steel apparently let go so quickly as to show no reduction in area, and the grain structure of the fractured surface had a similar appearance to that of a cast-iron

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* Presented at the Twenty-Fifth Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 16 to 19, 1944.
† Welding Consultant, Marinship Corporation, Sausalito, Calif.

fracture. In other words, it appeared that these fractures occurred so quickly, or through such a concentration of stresses, that the elements involved had no opportunity to grab hold and resist. Invariably tensile tests made from plates which had fractured showed that when subjected to such a gradual load the steel showed the normal reduction in area and grain structure and other standard physical properties.

2. *The Trigger.*—Invariably these stress fractures could be traced back to a "trigger" which set off the explosion. These "triggers" (sometimes called "stress risers") may be in the form of notches, sharp re-entrant angles, saddle welds, excessive and overwelding or other elements which produce local "hard spots" or other sharp local breaks in continuity.

A few factors which contributed to the above and required immediate attention were the following:

(*a*) Improved and more extensive welding planning and sequences, and prompt and complete observances of the same. This involves not only the welding operations, but also the proper preparation. It was evident that the welder should not be forced to weld anything that was not properly fitted and prepared. It was also evident that the use of automatic welding should be more carefully controlled and its operation restricted to work in the flat position only.

(*b*) A prompt review and correction of features of design which must not only be correct from the service viewpoint, but also from the welding viewpoint. Proper design for welding should avoid sharp changes in continuity and thicknesses and other conditions which would cause heavy local stress concentrations or the "trigger" points referred to above.

I believe the whole problem was quite well summed up in the statement of Lyle Wilson at a meeting here on Jan. 29, 1943, as follows: "Future success or failure of welded vessels depends entirely on the biggest failure at present in all shipyards today—that of Control. Since no welder can ever be permitted to decide for himself what is to be welded, it is obvious that responsible, aggressive supervisors must be trained and provided to take the initiative and *direct* men intelligently, watching at all times that previously allotted sequence is adhered to *100%*—and not 95% —since it is the disregarded 5% which causes the aggregation of small errors that are the constituents of the 'trigger' which sets off the explosion."

The First Crisis

At the time of the writer's survey of the *Schenectady* at Portland, Ore., I believe that my reaction to the complete failure of this new vessel with its extremley strong and rugged longitudinal construction was quite generally a universal reaction of finding it extremely difficult to believe one's own eyes in that such a failure actually could or had occurred, or how it was possible for residual stresses to be accumulated in the construction of such a welded vessel which would lead to such a tremendous and complete failure. However, after having one's nose right into the job in connection with the construction of our first tankers at Marinship, these doubts were soon swept away and it became obvious that the application of sound and proper welding sequences and procedures would constitute only one small element in the necessary control to assure that the unfortunate experience of the *Schenectady* would not be repeated. It was apparent that we were carrying on and performing operations, subsequent to our welding to approved sequences, which not only nullified any benefits from such sequences, but were setting up subsequent residual stresses of such a serious nature as to cause local failures of plating and other structural members.

The urgent need of controlling these unsafe practices which were interposing residual stresses into the structure on top of those already resulting from our normal welding operations, led to the calling of a meeting between local representatives of the Maritime Commission, American Bureau of Shipping and the Marinship Corporation. This meeting accomplished very definite results, established a sound mutual policy and took steps to eliminate or properly control the unsafe practices which had already been proved must be eliminated or properly controlled.

Memorandum of March 30, 1943, covering the results of this meeting together with the Agreement of March 28, 1943, subscribed to by the interested parties, follows:

MARINSHIP CORPORATION

March 30, 1943

On Sunday morning, March 28, 1943, a meeting was held in the American Bureau of Shipping Office in the Mold Loft, attended by Chester L. Nelson, Principal Hull Inspector, U. S. Maritime Commission, W. B. Murray, Surveyor, American Bureau of Shipping, John H. Anderton, Production Engineer, Marinship Corporation and Donald G. Maxson, Welding Consultant.

The purpose of this meeting was to discuss and arrive at a mutual understanding between the interested parties on the establishment of a basic policy in the construction of tankers at Marinship Corporation in a manner that would assure that every possible means was being taken to build these vessels with the aim of having a safe ship as free as possible from residual stresses and with the utmost assurance that all possible precautions would be taken to eliminate the possibility of any repetition of previous unfortunate failures in this type of vessel.

The recommendations attached hereto were submitted as a basis for discussion and after careful deliberation the principles outlined therein were approved unanimously.

It was mutually agreed that the building of a safe ship was subject to no compromise. It was felt, however, that in the attainment of this end it would still be possible to attain the following extremely important aims in the order noted:

1. Build ships as fast as possible to meet our urgent war needs.
2. Build them as economically as possible to get the utmost production out of the manpower and money available.
3. Build ships of good appearance that we can all be proud of.

All of the above aims can and will be attained by the full cooperation from top to bottom of the several agents involved in this important enterprise.

DONALD G. MAXSON
Welding Consultant

MARINSHIP CORPORATION

March 28, 1943

In order to have any assurance that we are following proper methods in the construction and welding of T2 tankers that will not repeat the unfortunate experience of the S.S. *Schenectady*, the following recommendations must be observed:

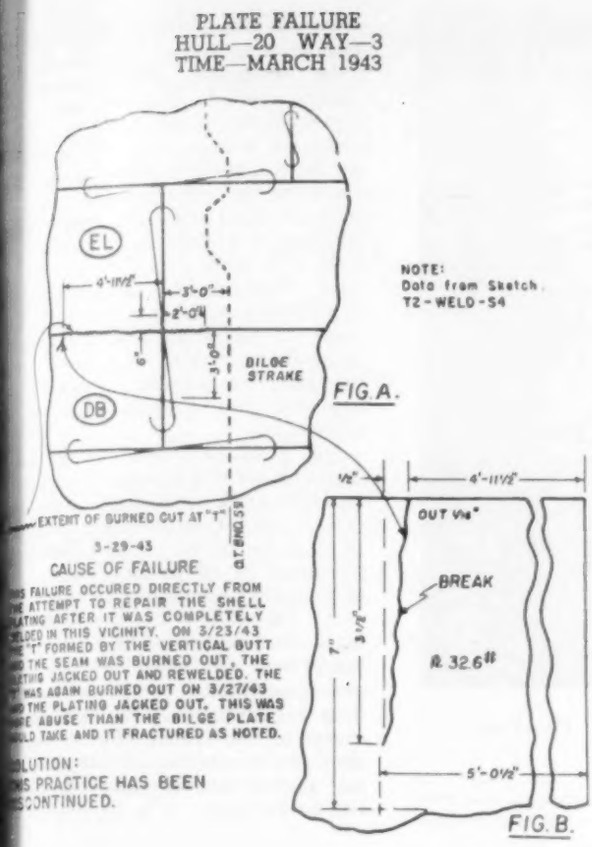
1. The following unsafe practices must be discontinued:
   (*a*) The use of strongbacks and torch heating of shell and deck plating after welding, or the cutting out of seam and butt welds for repairing and rewelding.
   (*b*) The cutting of test plugs in shell and deck except on reference to and approval of U. S. Maritime Commission, Principal Hull Inspector, American Bureau of Shipping, Principal Surveyor and Welding Consultant.
   (*c*) The practice of flushing off shell seam and butt welds and rewelding except on an O.K. of Welding Engineer or Welding Consultant. If still in dispute, refer to Principal Hull Inspector, U. S. Maritime Commission; Principal Surveyor, American Bureau of Shipping and Welding Consultant.
   (*d*) The adding of additional and superfluous stringbeads to welds on the skin of the ship except as noted in (*c*) above.

The above particularly applies to the skin of the ship and major bulkheads, etc., after they have been welded in position in sequence.

2. Inspection:
   (*a*) All side shell and deck sections, main bulkheads and other major assemblies to be inspected prior to erection on ways. This welding inspection to be complete and final and no further repairs to be made on such welds except to stop leaks as shown on hydro (or air) tests.
   (*b*) The only welding inspection on the ways will be on field welds made on the ways and this inspection and any necessary repairs to be made within 24-hr of completion of such welds (in sequence) and to be final. This is necessary in order to assure that such repairs are made before the welding sequence has progressed well beyond the area involved.

Fitting

Safe welds cannot be made on the important joints on the skin of these vessels by bridging across excessive openings. No



CONTROLS REQUIRED FOR SAFE AND ECONOMICAL CONSTRUCTION OF WELDED SHIPS

Fig. 1—Unsafe Practices—Splitting and Repairing

weld shall be made where openings in the plates exceed 1/4 in. Where the opening is of a large extent the section is to be taken loose and refaired and properly welded. Where the excessive opening is local, one or both plate edges may be built up carefully with welding and carefully dressed to the proper opening and bevel before the weld is made.

Unfairness

The worst cases of unfairness are caused by poor preparation such as having a bulkhead or other transverse member off of the molded line and when the plating is pulled in and welded to such an unfair member, unfairness is built right into the vessel. This must be corrected by more careful checking and inspection prior to welding.

Welding

Welding of all major welds on the skin and on major and vital sections can and will be done to approved welding procedures and sequences and still not restrict the expeditious construction of these vessels.

DONALD G. MAXSON
Welding Consultant

APPROVED:
Wm. B. Murray,
American Bureau of Shipping
John H. Anderton,
Production Engineer
Chester L. Nelson,
U. S. Maritime Commission

The above has been quoted in its entirety as this agreement has to a large extent become our "Bible" and the policy and premises contained therein have proved consistently to be sound not only in the controlling of major unsafe practices referred to therein, but further it established a proper and sound policy for inspection; and of no less importance it was one of our first main steps in the diagnosing and prescribing to the patient as a "joint venture."

Joint Venture

Over and above anything else, the successful control of the many elements involved in the safe and economical construction of welded ships depends on the program being a "joint venture" of all interested parties and agencies. Any conception or idea of properly controlling such elements by having a welding engineer stuck off somewhere in the corner as a more or less necessary evil and without the proper backing and cooperation of all interested parties cannot possibly solve such a vital problem.

Despite the tremendous accomplishments during our war effort the construction of Boulder Dam still remains as a monument of modern construction efforts as well as being the birthplace of "joint venture." It was on the same principle of pooling the best talent and resources of similar groups on the "joint venture" basis that led to the organization and establishment of Marinship and associated shipyards. Likewise the efforts to control the many elements involved in the safe and economical control of building tankers here has been a "joint venture" with all interested parties and agencies acting as consulting physicians.

Consulting Physicians

It became very evident to the family physician, early in the case, that all possible aid would be required from the consulting physicians, more particularly in the following:

(*a*) *Management.*—The whole backbone of the success of our program has been the 100% backing and full cooperation of Management as represented by Ray Hamilton, Production Manager.

(*b*) *Government Agencies.*—There has been a very close and cooperative tie-in with the Government agencies as represented by W. B. Murray of the American Bureau of Shipping, Chester Nelson and his successor W. B. Fawke of the U. S. Maritime Commission, to carry out the policy and principles as outlined in the memorandums of March 28 and 30, 1943 as noted heretofore.

(*c*) *Engineering.*—One of the most important factors in the safe construction of

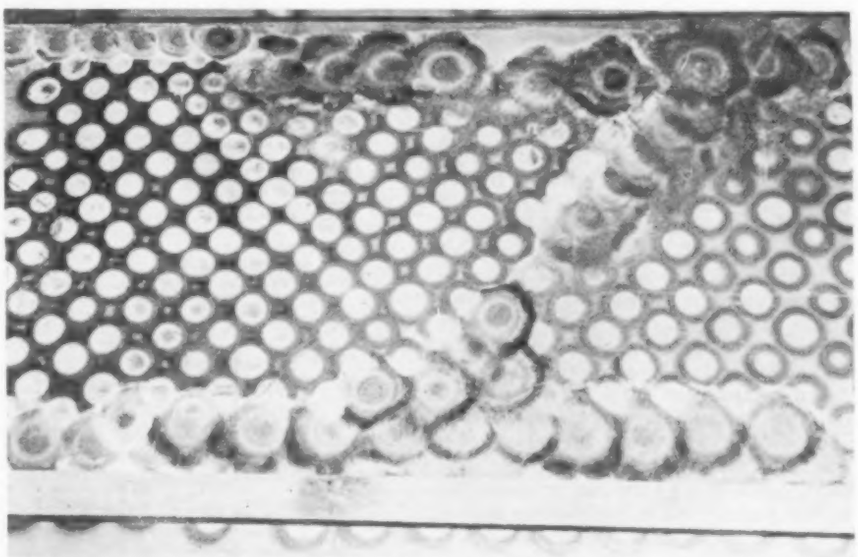


Fig. 2—Unsafe Practices—Spot Shrinking "The Smallpox" Time: March, 1943

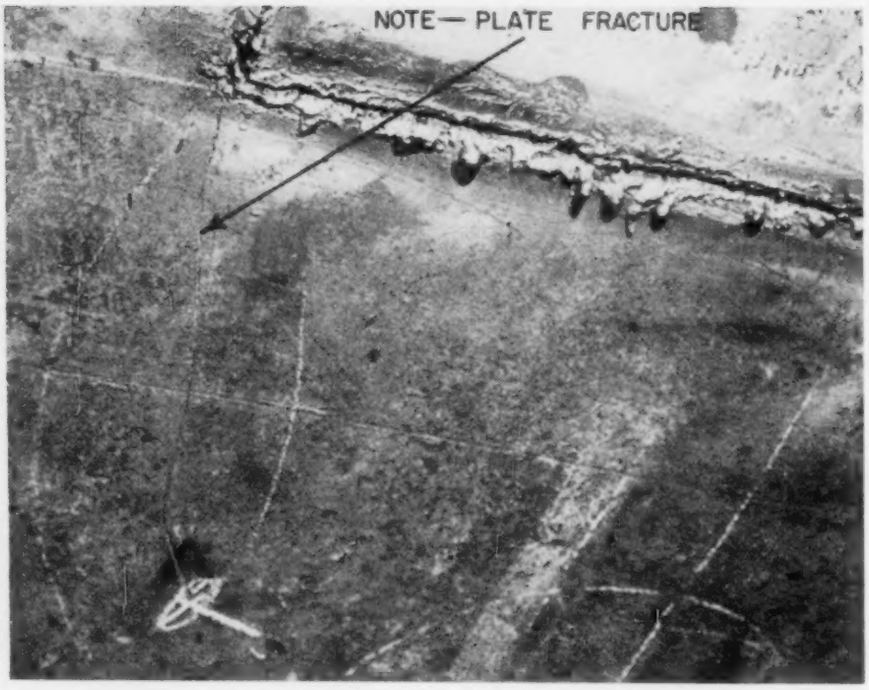


Fig. 3—Unsafe Practices—Notch Burning. Time: April, 1943. Note: Plate Fracture

tankers, particularly in our early stages, was to correct the many notches, square corners and other unsafe elements as shown on our earlier plans. This phase has been controlled through the efforts of Dick Grambow, Naval Architect, who has given the fullest cooperation from the start.

(*d*) *Production and Craft Supervision.*—All of our efforts in the control of the many phases involved would have been of no benefit if such controls, procedures, sequences and the like, were not adhered to in the field. The major part of our entire program has been accomplished by the cooperation and action of Jack Hardie, General Superintendent of the Ship Construction Division, and Dave Davidson, General Superintendent of the Plant Division, and their staffs in the field.

Base Hospital

When I was called in to act as the family physician, I was assigned an able assistant in the person of R. E. Smith, Welding Engineer. From this beginning and through various changes initiated by the production manager, the writer's staff gradually developed into what became known as the Work Standards Division.

In the early summer of 1943, the production manager transferred Ray Brown to act as yard consultant under the writer covering the chipping, riveting, flanging and other steel crafts along the same lines as our efforts had been heretofore confined to the welding and burning crafts.

The Work Standards Division, which has since that time been composed of a small group of top personnel or specialists in the various crafts, performing among other things the following functions:

(*a*) *Welding and Craft Engineering.*—This work consists of the preparation of welding and craft sequences and procedures in cooperation with the Production and craft supervisory force.

(*b*) *Field Engineering.*—This section consists of a small group of engineers who tie in the production divisions and the engineering department on all welding and hull problems, and act as a central agency for accumulating, screening and utilizing of the best thoughts, suggestions and ideas yard-wide and craft wide.

(*c*) *Standards.*—The Division acts as a central agency for the establishment of yard-wide craft and work standards. This work is performed on the premise that standards are not necessarily fixed, but fluid to meet changing conditions.

(*d*) *Inspection.*—The procedures, sequences and standards of workmanship and so forth, are monitored by a skilled group of welding and hull specialists predicated, however, on the premise that the prime responsibility for the proper observance of all procedures, standards and the like, rest with the production and craft supervision.

(*e*) *Weld Layout.*—This unit interprets and lays out on the steel parts in chalk or paint the weld dimensions, increments for intermittent welds, weld bevels, weld deletions, sequences, etc., as shown on the approved plans, specifications and sequences.

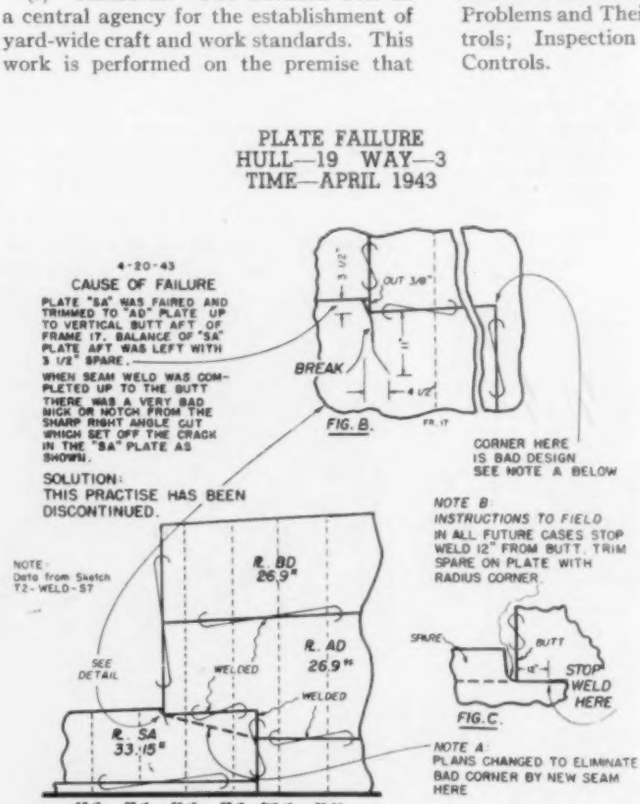
(*f*) *Weld Equipment and Supplies.*—This unit not only handles and distributes all welding rod, but maintains a close control to assure that the proper rod is used in its proper place. It also controls the placement of all welding machines and other welding supplies and equipment.

(*g*) *Internship.*—The Division has also been a training ground for a great deal of the present production and craft supervision, particularly in the welding craft. This has given us in the field, men in charge of the welding who are not only successful producers, but also who have had a good welding engineering training and background.

PART III
THE INDIVIDUAL PRESCRIPTION

In outlining some of our individual prescriptions or controls we will endeavor in a general way to cover the following ground—Sequences and Procedures; Elimination of Unsafe Practices; Design Problems and Their Solutions; Craft Controls; Inspection Controls and Critical Controls.

PLATE FAILURE
HULL—19 WAY—3
TIME—APRIL 1943


4-20-43
CAUSE OF FAILURE
PLATE "5A" WAS FAIRED AND TRIMMED TO "AD" PLATE UP TO VERTICAL BUTT AFT OF FRAME 17. BALANCE OF "5A" PLATE AFT WAS LEFT WITH 3 1/2" SPARE.
WHEN SEAM WELD WAS COMPLETED UP TO THE BUTT THERE WAS A VERY BAD NICK OR NOTCH FROM THE SHARP RIGHT ANGLE CUT WHICH SET OFF THE CRACK IN THE "5A" PLATE AS SHOWN.
SOLUTION:
THIS PRACTISE HAS BEEN DISCONTINUED.
3 1/2"
CUT 3/8"
BREAK
4 1/2"
FIG. B.
CORNER HERE IS BAD DESIGN SEE NOTE A BELOW
NOTE B
INSTRUCTIONS TO FIELD
IN ALL FUTURE CASES STOP WELD 12" FROM BUTT. TRIM SPARE ON PLATE WITH RADIUS CORNER.
NOTE:
Data from Sketch T2-WELD-S7
R. BD 26.9"
R. AD 26.9"
R. 5A 33.15"
SEE DETAIL
WELDED
WELDED
SPARE
BUTT
12"
STOP WELD HERE
FIG. C.
NOTE A:
PLANS CHANGED TO ELIMINATE BAD CORNER BY NEW SEAM HERE
FR. 15 FR. 16 FR. 17 FR. 18 BHD. 19 FR. 20
FIG. A.

CONTROLS REQUIRED FOR SAFE AND ECONOMICAL CONSTRUCTION OF WELDED SHIPS

Fig. 4—Unsafe Practices and Design

It has been the writer's experience, particularly among the welding fraternity, that a clear and proper definition of sequence and procedure is quite rare. On the other hand, there appears to be a very simple answer to each as follows: sequence is "when" and procedure is "how." In general, sequence or "when" is very properly a directive; on the other hand, procedure or "how" is not. In other words, it is not good psychology for the engineer or consultant to tell the craft or production supervisor how to do his job in the form of a directive. Our approach here is that the master sequences the "when" the welding or other craft operation shall be done are by nature a directive, but all procedures stating "how" are issued under the signature of the craft or production supervisor and bear the approval of the welding consultant's office. These sequences and procedures which cover a wide range are issued in booklet form in the following breakdown:

(a) *Series No. 1*—"Master Welding Sequences and Procedures."—This book covers the group of sequences and procedures essential to control the proper operation and safe welding of these vessels. The master sequences have been submitted to and approved by both the American Bureau of Shipping and the U. S. Maritime Commission.

(b) *Series No. 2*—"Hull and Welding Inspection Procedures."—This group of procedures cover the wide range of inspection requirements, more particularly the setting up of the proper controls to carry out the policy on inspection as outlined in Article 2 of the Agreement of March 28, 1943.

One of the most important of these controls is that affecting the skin of the vessel and that portion consisting of all shell and main deck units which comprise the water and oil-tight integrity of these ships. This inspection is covered on a "joint venture" basis and signed off by U. S. Maritime Commission and Company representatives using the following form of control:

In a similar manner and with a similar form of release, all field welds performed

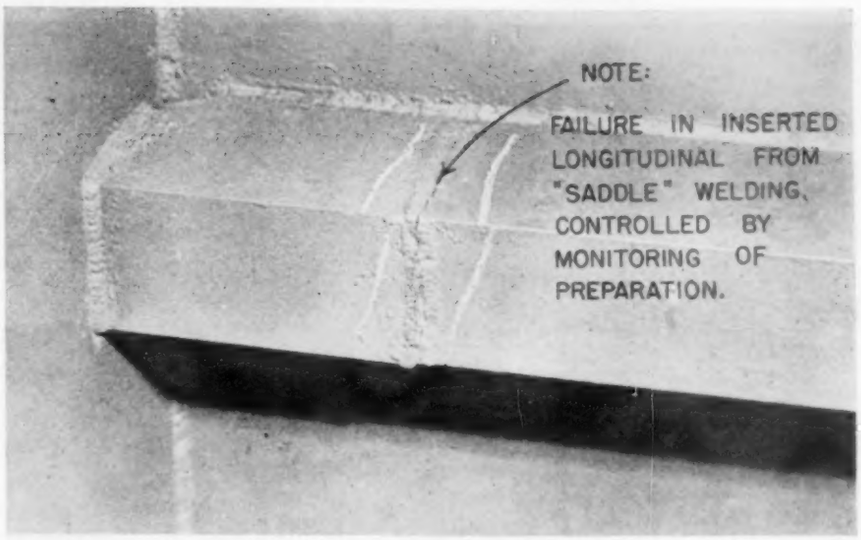


Fig. 5—Unsafe Practices—Saddle Welds. Time: January, 1944. Note: Failure in Inserted Longitudinal

use of inserts and other major repairs which have been likewise handled as a "joint venture" between the Government representatives, the Production force and the Work Standards staff. This is controlled by a rigid inspection to assure that such inserts and the like have been properly prepared for welding to the approved procedures and standards. This work is controlled through the following form of release:

In a similar manner an inspection is made covering hull and welding operations for all the major assemblies manufactured in the Plant Division and a wide variety of similar operations.

(c) *Series No. 3*—"Technical Procedures."—This series of procedures covers the question of weld layout, weld bevels with their proper tolerances for preparation and welding, deep fillet technique of welding and many other technical procedures and the like.

(d) *Series No. 4*—"Hull and Welding Work Procedures."—This series covers various craft procedures such as burning procedures for ways and docks, fitting and welding procedure for longitudinal through brackets at bulkheads, fitting and welding procedure for Unionmelt welding and the like.

(e) *Series No. 5*—"Testing, Training and Personnel Procedures."—This series covers the established procedures for training, testing and other personnel problems of the welding, burning and chipping crafts.

(f) *Series No. 6*—"Work and Time Saving Procedures."—This series covers a grouping of the many and various pro-

Release No. ——— MARINSHIP CORPORATION Hull No. ———

PRODUCTION DEPARTMENT
WORK STANDARDS—WELDING DIVISION

"Insert" Release Plant Date———

1.——Inserts required by (check one) PreHull / Ways / Docks on———— (Description of member inserted)

2. Above inserts due to———— (state reason for insert)

3. Above inserts have been prepared to the requirements of the Welding Consultant's Procedure of 6/28/44.

For U.S.M.C. or A.B.S.

For Welding Consultant

For Production
Recorded and distributed on
————1944.

Procedure Co-ordinator

MARINSHIP CORPORATION
WORK STANDARDS—WELDING DIVISION

KIN" WELDING RELEASE (PLANT DIV.) DATE———1944

e Shell and/or Main Deck Welding on Sections H.....

(Description of Section)

been completed by the Plant Division, inspected and passed for erection on ways. further repairs are to be made on such welds except in accordance with Welding nsultant's Procedure of 4/8/43 and proper release from the Welding Engineer's Office ay 1).

U. S. Maritime Commission

For Welding Consultant

Copies: White to Ship Const. Yellow to Plant Division
Blue to U.S.M.P.C. Pink retain in Book

the ways are jointly inspected, re- ed if necessary and signed off within hr. of their completion in sequence.

Another extremely important phase re- ring proper control has been that of the

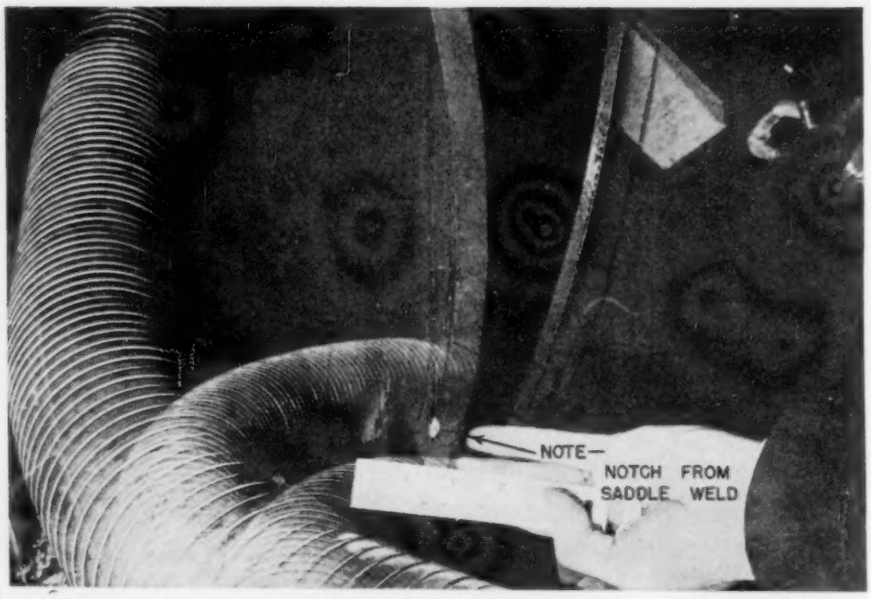


Fig. 6—Unsafe Practices—Saddle Welding on Cargo Hatches (Vendor Item). Time: 1943. Note: Notch from Saddle Weld

cedures which have been prepared to eliminate and control such things as overwelding and other procedures which will increase our over-all efficiency.

(g) *Series No. 7*—"Jack Clamp Procedures."—This group covers a very complete study and work in the field to utilize to a great advantage the extremely useful jack clamp.

Elimination of Unsafe Practices

The elimination of unsafe practices which superimpose additional thermal stresses subsequent to the completion of the welding operations has been one of the most important steps in the control and elimination of construction failures. Article 2 of the Master Agreement of March 28, 1943, outlines some of the unsafe practices which were discontinued at that time.

The following illustrations in the form of photographs or sketches illustrate some of the early failures caused by such unsafe practices and also show the steps taken to control same.

(a) *Cutting Seam and Butt Welds for Refairing and Rewelding.*—Figure 1 shows a failure occurring in a bilge plate in March 1943 from the unsafe practice of ripping major seams and butts out after being welded in sequence and jacking out and rewelding. It will be noted that this practice has been discontinued and fairness of such structure is maintained by a rigid control of proper preparation, strong backing, etc., before welding.

(b) *Spot Shrinking—The "Smallpox."*—Particular attention is invited to Figure 2 which we aptly call the "Smallpox." How anyone can ever become excited about welding sequence from a stress viewpoint and countenance the deliberate injection of stresses by such shrinking operations is a mystery. The proper control of the acetylene torch is often more essential to safe construction of welded ships than the proper control of the welding arc. To properly and completely control this extremely unsafe practice, it became necessary on instructions from the production manager to remove all shrinking torches from the field and lock them up in the tool room. Under proper supervision a reasonable amount of shrinking may safely be performed on the light plating of superstructure, more particularly in the way of portlight and door openings. However, this is one operation which must at all times be under close control if we are in any way interested in controlling residual stresses.

(c) *Unsafe or Notch Burning.*—Figure 3 shows failure occurring in April of 1943 from unsafe or notch burning during preparation and fitting of shell plate. This failure is shown in more detail on Fig. 4. The question of square-cornered notch burning has been one which has taken the strongest procedures to properly control both in the field of craft control as well as in the control of proper design to eliminate and insure that all torch cuts have radius corners.

(d) *Saddle Welds.*—The unsafe practice of saddle welding or the running of a couple of surface passes on the outside of unprepared joints has been the cause of several failures as will be noted from Fig. 5 which illustrates a failure in an inserted longitudinal member. Figure 6 illustrates the saddle welding of cargo hatches.

These hatches were furnished by vendors. While this unsafe condition was discovered before any failures occurred, it was necessary to bevel all these joints and reweld in a 100% manner. This practice has been controlled by the issuance of proper procedures to assure that all such joints are properly prepared before welding as has already been noted under the procedure set up for the controlling of inserts.

(e) *Overwelding.*—Figure 7 illustrates a recent failure occurring in the fore and aft stay pads on the main mast caused by excessive overwelding. This stay pad, which was a vendor's item, was welded to a half-inch plate on the cross trees, the plan calling for a half-inch fillet weld. Apparently, the vendor not realizing the basic premise that the size of the weld is always determined by the thinner member based his welding on the very heavy pad and the actual weld was approximately a $1^1/_2$-in. fillet which caused undue stresses which together with an extremely bad notch condition in way of the angle connection caused the fracture of two of these pads as noted. The question of overwelding on our work here has been

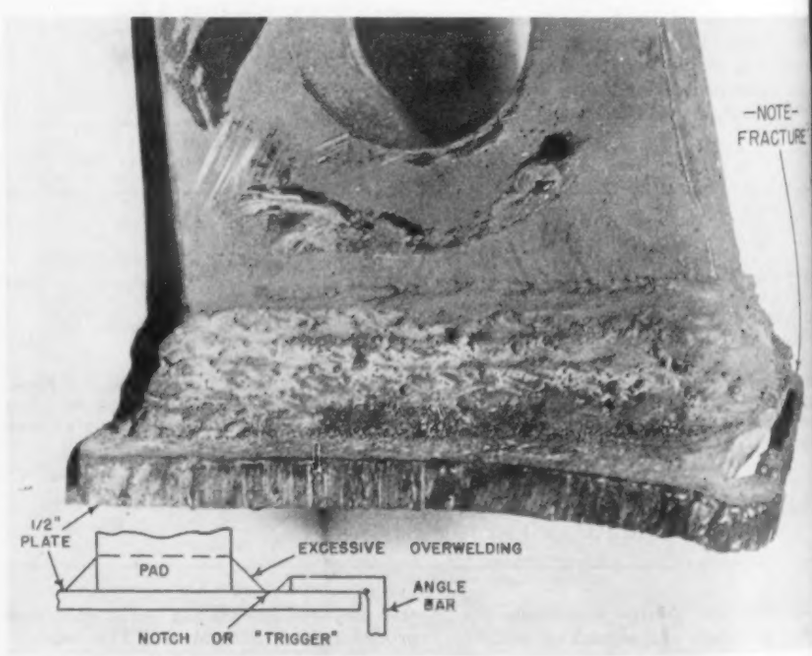


Fig. 7—Unsafe Practices—Overwelding. Time: July, 1944. Note: Fracture in Plate and Notch or Trigger

which has been thoroughly covered not only by memorandums, but by illustrative sketches. This subject has been attacked from the view of safe construction as well as economy.

Design Problems and Their Solutions

From the start, in cooperation with the naval architect, prompt steps have been taken to eliminate bad design in the nature of notch conditions, square corner cuts and sharp re-entrant angles. Figure 8 illustrates the original sharp notch condition of the fashion plates of the midship and fore and aft deck structures at the top of the sheer strake. This notch condition was one of the factors involved in the failure of the S.S. *Schenectady*.

Figure 9 shows the present tying in of the fashion plate to the top of the sheer strake in a fair and steamlined manner.

In addition to the above, the naval architect's office has taken steps to eliminate all square corner doublers, pads or other attachments on the main deck or other important structural members as well as calling for radius corners on all openings and penetrations.

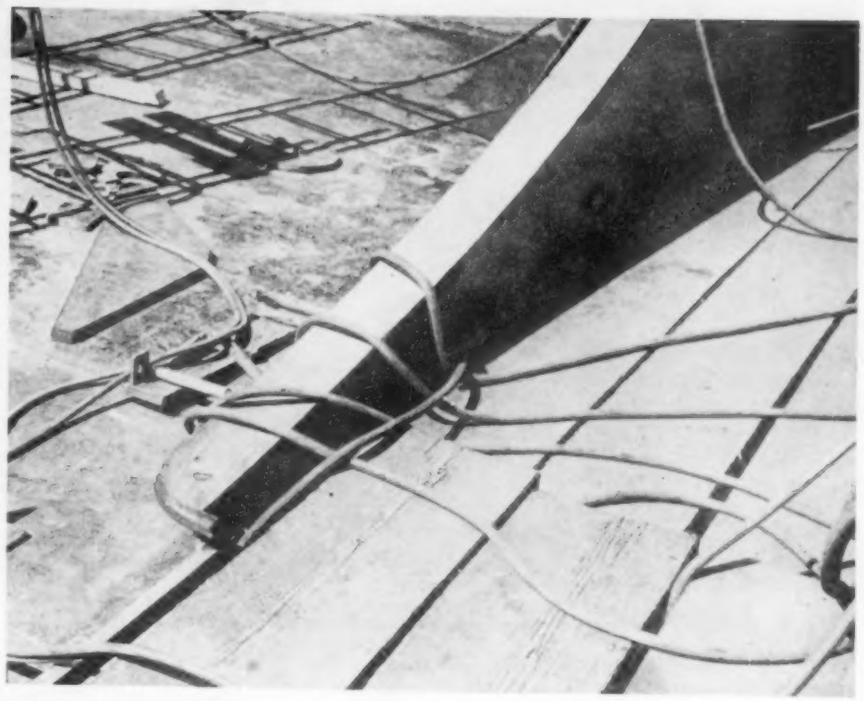


Fig. 8—Design Problems—Notch on Sheer Strake at Fashion Plate. Time: February 1943

Craft Control

Of utmost importance in the safe and economical construction of welded ships is the proper control of the various craft operations on the building ways to the master sequences. These operations are controlled by the use of "Field Production Cards" as indicated below:

A set of filing racks is provided in each hullmaster's shack for the movement of these cards through the various divisions; each division represented (Rigging, Shipwright, Fitting, Welding) having its individual rack. The control of all the cards through the divisional racks are maintained by the hull engineer. The procedure is as follows:

FIELD PRODUCTION CARD
STERN ASSEMBLY TO POOP DECK
(Description of Section)

Sect. No. H-292 Card No. 486 Hull No. 60

LANDED: Date ____ Shift ____ Rigging Div. ____
SET: Date ____ Shift ____ Shipwright Div. ____
FITTED: Date ____ Shift ____ Shipfitting ____ Div. ____
WELDED: Date ____ Shift ____ Welding ____ Div. ____
Weight of Section 16.1 Tons
Total Welding 258 Feet

Each hull erection section is represented by such a numbered master card, the numerical sequence of which corresponds with the hull erection sequence as prepared by the Planning Division. The first function of the master cards is to assure the landing and erection of the hull sections to this sequence which is automatically maintained by the Rigging Division using them as work orders in their numerical sequence.

Every master card, in turn, supports a set of corresponding numbered blue cards which enumerate in detail the fitting and welding operations required on that particular section together with the exact welding footage, the summation of which equals the footage indicated on the master card.

1. When any required section is ready for landing, the hull engineer places the corresponding master card in the rigger's rack where it represents a work order for landing that section on the hull.

2. When the section has been landed the master card is signed off by the rigger foreman and transferred to the shipwright's rack where it in turn acts as a work order for the setting of the section.

3. When the shipwrights have set the section the card is signed off by the shipwright's foreman and transferred to the shipfitter's rack. At *this time* a set of corresponding numbered blue cards is attached to the master card and from there issued to the shipfitter crew by their foreman in the form of work orders. The *master card* is then removed from the rack and filed for reference having accomplished its purpose.

4. As soon as the shipfitters complete the fitting as called for on the blue cards in their possession, the work is inspected by their foreman and then signed off as completed. The card is then transferred to the welder's rack and acts as a work order for the welding. On the completion of the welding and inspection by the welding foreman, the cards are signed off for final completion.

There are a total of 526 hull sections per vessel, each of which is controlled by a master card which is broken down into 2024 blue cards covering the individual fitting and welding operations. These master cards cover a total of 4855 tons of steel and 100,418 ft. of erection welding.

In addition to controlling the craft operations to sequence, the cards furnish each craft with convenient work assignments and furnish the Progress Division with accurate data for the preparation of yard progress reports.

Critical Control

Figure 10 outlines the most critical area of the vessel requiring rigid control from a stress viewpoint and also outlines some excerpts from the procedures established for the elimination of all possible notch conditions on the top of sheer strake, the fashion plates or on the main deck. Any notch condition in this area is the equivalent of the hacksaw cut given the nick break test plate prior to the breaking of such plate for examination.

Lack of Control

Figure 11 shows a major failure in a bilge plate which occurred in the first part

Fig. 9—Design Problems—Streamlining Fashion Plate at Sheer Strake. Time: 1943

of April of this year. This is the only failure of a major nature which has occurred in months and is a good example of the premise that once the skin of the ship is welded in sequence, additional stresses cannot be superimposed through the application of further thermal stresses. This failure was caused by the improper and careless removal of a lifting pad by an inexperienced burner who gouged into the shell plate; thus through his burning operation causing additional stresses. The final straw was the application of the several stringbeads of welding to cover this defect which resulted in a 2-ft. fracture of the bilge plate. It will be noted that this panel was already highly stressed from the welding of the longitudinals and frames and the superimposing of these additional stresses was more than the steel could stand. The safe removal of such lifting pads has been thoroughly covered by taking the following steps: firstly, in all instances where such pads do not interfere with other installations or proper movement, they are frozen and not removed. Secondly, in other places they are removed by being burned off neatly just above the weld and no scarfing of the weld permitted. Lastly, on tank tops and decks where the complete removal of the pad and the welding is required scarfing is restricted to strict supervision and procedures or else insistence is made that such pads be chipped free.

PART IV—THE INQUEST

The Patient Survives

After a careful review of the accomplishments to date, the findings of the jury show that there have been no service failures of any of the tankers delivered from Marinship. This fact in itself is no proof that the controls which have been set up and operated are in themselves the sole reason for these results, however, it is felt we have come a good part of the way in taking steps to build safe and economical all-welded ships.

Our most crucial period is with and ahead of us, particularly in view of the very rapid reduction of our construction time on the ways and at the outfitting docks which so materially cuts down the time given nature to adjust and relieve residual stresses. Also, we are faced with the problem of complacency which always results when no trouble arises over a considerable period of time.

One of the accomplishments which we have definitely obtained through the combined efforts of all, has been to continually improve our standards of workmanship despite our increased rate of production. This improvement covers all phases and all crafts from the drawing board to the delivered ship.

Attention is invited to Fig. 12 which shows the clearing of the sheer strake of attachments and breaks in continuity the streamlining of the fashion plates and the fairness of the hull maintained by proper inspection and preventive methods rather than by the extremely unsafe practices of ripping butts and seams, refairing and the like.

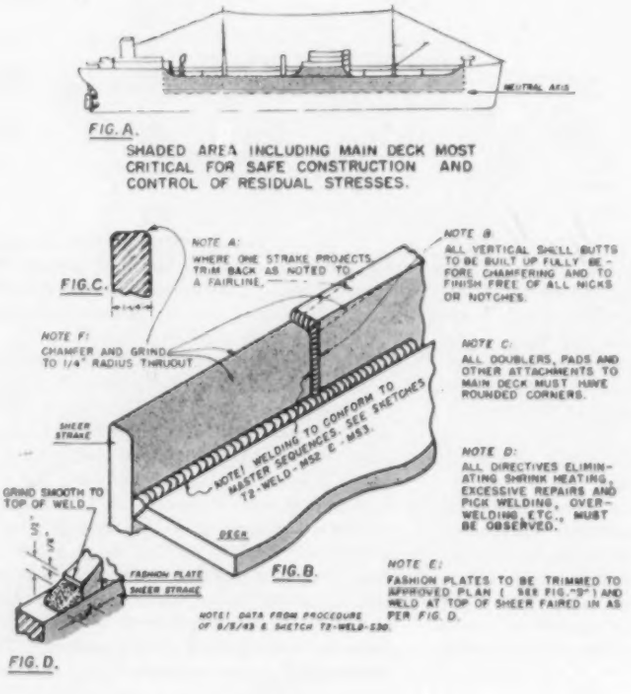
The Patient Thrives

The first aim of our basic policy is the building of a safe ship. However, during 1944, we have placed a great deal of pressure and emphasis on efficiency and economy. This has been particularly true in regard to the welding operations which are a yardstick of the over-all job. Our basic code for efficiency has been that the efficient and economical job can only be the one that is done right the first time, thus eliminating the necessity of subsequent repairs or reworking. This premise is not only sound for economy, but also tells in very strongly in the safety factor. Within the past two months, we have cut our construction time on the ways, practically in half and maintained the quantity and quality of our way welding with practically no increase in the welding force.

Theoretically the perfect welded ship would be one that was completely welded to all plan and specification requirements with the absolute minimum amount of welding rod and without any repairs, re-welding, overwelding or other lost material and motions of this nature.

For the past several months we have endeavored to control and exert pressure toward such a result. In connection with this, attention is invited to Fig. 13 (A) which shows the total amount of welding

SHIP UNDER HOGGING LOAD


NEUTRAL AXIS
FIG. A.
SHADED AREA INCLUDING MAIN DECK MOST CRITICAL FOR SAFE CONSTRUCTION AND CONTROL OF RESIDUAL STRESSES.
FIG. C.
NOTE A:
WHERE ONE STRAKE PROJECTS TRIM BACK AS NOTED TO A FAIRLINE.
NOTE B
ALL VERTICAL SHELL BUTTS TO BE BUILT UP FULLY BEFORE CHAMFERING AND TO FINISH FREE OF ALL NICKS OR NOTCHES.
NOTE F:
CHAMFER AND GRIND TO 1/4" RADIUS THRUOUT
NOTE C:
ALL DOUBLERS, PADS AND OTHER ATTACHMENTS TO MAIN DECK MUST HAVE ROUNDED CORNERS.
SHEER STRAKE
NOTE! WELDING TO CONFORM TO MASTER SEQUENCES. SEE SKETCHES T2-WELD-M52 E - M53.
NOTE D:
ALL DIRECTIVES ELIMINATING SHRINK HEATING, EXCESSIVE REPAIRS AND PICK WELDING, OVERWELDING, ETC., MUST BE OBSERVED.
GRIND SMOOTH TO TOP OF WELD
DECK
FIG. B.
NOTE E:
FASHION PLATES TO BE TRIMMED TO APPROVED PLAN (SEE FIG. "D") AND WELD AT TOP OF SHEER FAIRED IN AS PER FIG. D.
FASHION PLATE
SHEER STRAKE
NOTE! DATA FROM PROCEDURE OF 8/8/43 & SKETCH T2-WELD-530.
FIG. D.

CONTROLS REQUIRED FOR SAFE AND ECONOMICAL CONSTRUCTION OF WELDED SHIPS

Fig. 10—Critical Controls

rod consumed per hull at delivery from hull 40 to 49, inclusive. It will be noted that there has been a gradual and continual reduction in the amount of welding rod required to complete these vessels. This is a definite indication of increased efficiency and saving in material and man hours.

Figure 13 (*B*) shows the results accomplished through education, procedures and rod control in increasing the use of 3/16-in. all-position welding rod over the smaller 5/32-in. diameter rod which is so definitely a function of increased efficiency.

Conclusion

To sum up a few of the most pertinent premises necessary to the construction of safe and economical all-welded ships, it appears very evident that the following must be observed:

(*a*) *A Basic Policy.*—A basic policy such as outlined in the memorandum of March 30, 1943, is just as essential to the successful approach of solving the "subtle ailments" of weld ship construction as charts are to the mariner in approaching an unknown shore.

In the approach to the attainment of such a policy it must be realized that at best only a limited result can be obtained unless the entire problem is attacked and solved on a "joint venture" basis between all the agencies, departments, divisions and crafts involved.

(*b*) *Control of Residual Stresses.*—The fact must be faced that we will not get to first base in the control of residual stresses in all-welded ships until we get over the idea of attacking this vital problem as being exclusively a function of welding. These stresses and distortions set up in the base metal are due to the property of the steel which upon the application of heat, first expands and then upon cooling contracts beyond its original limits. This property is clearly demonstrated by the fact that a cube of steel if repeatedly heated and cooled will ultimately take the form of a sphere. Added to the contraction or shrinkage of the base metal is the shrinkage of the deposited weld metal itself, which is in reality cast metal and shrinks similarly to any other steel casting as it cools. Therefore welding enters the picture only because of the heat generated by the arc and not because of any other inherent deviltry.

It also must be realized that the most dangerous stresses are those which are superimposed upon others produced by the welding operations.

(*c*) *Inspection.*—There must be a new conception of the relationship between the contractor and the inspection agencies. The old premise of waiting until the job is finished and calling on the inspector to reject or accept, results in dangerous repairs after the vessel is completely welded in sequence and cannot continue if we are to build safe welded ships. It is just as important to see that inspection and any necessary repairs be made in proper se-

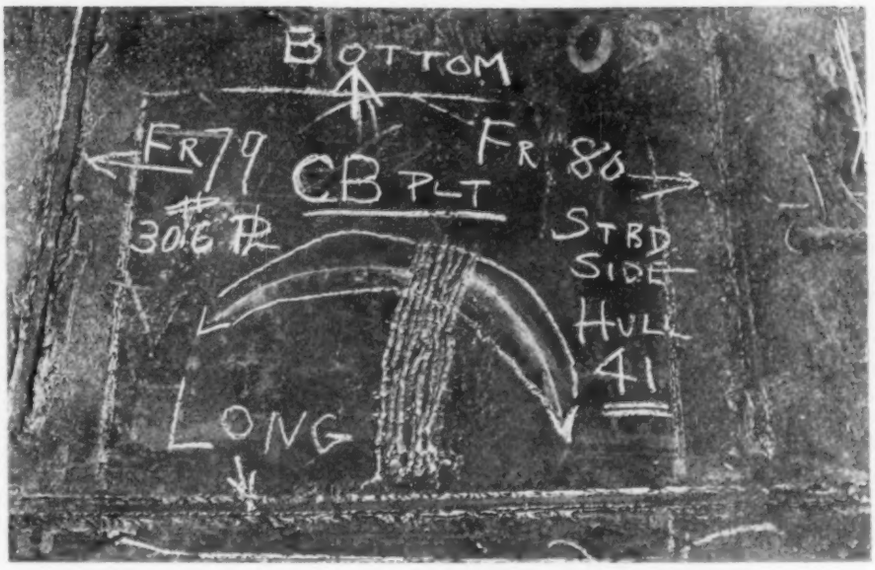


Fig. 11—Lack of Control Failure of Bilge Plate. Time: April 1944

Fig. 12—The Patient Survives. Time: August 1944
Note: Removal of All Attachments to Top of Sheer Strake, Streamlining of Fashion Plates and Fairness of Shell by Proper Inspection and Preventative Measures

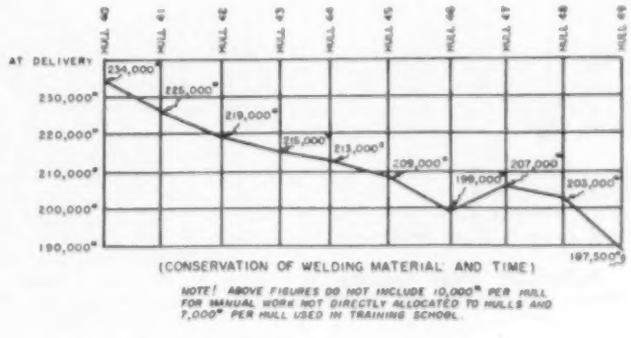


Fig. 13a—Total Consumption of Welding Rod per Completed Hull at Delivery

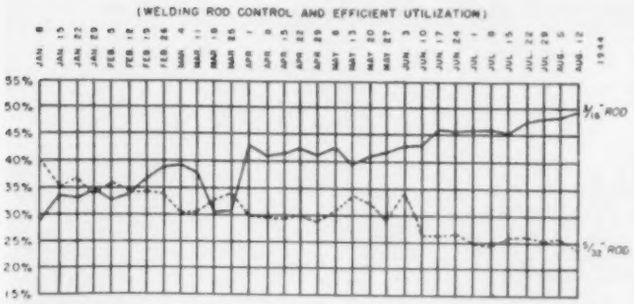


Fig. 13*b*—Welding Rod Consumption for Year 1944. Per Cent of Use $^{5}/_{16}$ In. vs. $^{5}/_{32}$ In. Diam. Electrodes. Percentage Based on Yard Total of All Sizes

quence and at the proper time, as it is to weld to a proper sequence.

Welding inspection should go back to the inspection of the preparation. A joint which is properly prepared to standards will be a safe welded joint as it is practically impossible with perfect fitting and preparation to obtain anything but a safe weld. One good complete and thorough inspection of welding at the right time is the answer and no further inspection should be necessary except where the human element has missed or erred, or where tests show leaks or other necessity for further repairs.

Company inspection should be limited to a small group of thoroughly and competently trained men who know welding thoroughly, and the responsibility for doing the job right the first time should at all times remain with the craft supervision. Permitting a large group of company inspectors and other supervision to chalk and mark up welding repairs promiscuously relieves the craft supervision of such responsibility.

(*d*) *Efficiency.*—There is no substitute for the fact that the only real efficiency in welded job is the one that is done right the first time. This of course means that we must have all the proper preparation prior to welding and following this the welding must be properly done, to standards without overwelding and other wasteful efforts. In this connection it must be realized that the need of "leaving undone those things which should be left undone is as essential as doing those things which should be done."

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(*Continued from page 240*)

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Fast New M-24 Combat Tank Unveiled

By Walter Haise*

A NEW, fast, light tank with automatic drive through eight speeds forward and four reverse, mounting a 75-mm. cannon, has now been lifted from the Army's restricted list and it was disclosed that the armor plate hull (or body) has been in production for months by The Heil Co., Milwaukee.

The new combat weapon has fire power equal to that of a medium tank, speeds over 40 miles an hour, and has been literally custom-built to the design of "GI Joe" on the active battle lines. Designated the M-24 it supersedes the famous M-5, or "Honey," also encased in Heil-built hulls, and which the Army called "the fastest and most maneuverable combat weapon of its type in use by any belligerent on any front."

The M-5 has been replaced by the new M-24 on the basis of recommendations from Army officers and engineers who as "technical observers" spent months on Mediterranean and European fronts in actual battles. To these suggestions were added the best features gleaned from a study of captured enemy tanks and after observation of British and Russian combat weapons.

Principal advantages of the new M-24 are: (1) greater fire power (the 75-mm. cannon replaces a 37-mm. on the M-5); (2) lower silhouette for reconnaissance and observation missions (the new tank has an over-all height of less than 87 in. and a hull height of less than 5 ft.); (3) sloped surfaces for protective advantages (all important armored surfaces including the turret are slope up to 45°) (4) greatly reduced ground pressure in conjunction with new track and suspension for negotiating marshy terrain; (5) greater maneuverability and doubled obstacle climbing ability even at the expense of some speed.

The "power train" of the M-24 consists of two Cadillac V-type, 8-cylinder engines basically identical with those used in peacetime automobiles, and two Hydra-Matic transmissions operating through a power transfer unit. The newly designed automatic drive provides eight forward speeds, with a manual control between the upper and lower ranges and four speeds in reverse, automatically selected.

Front View of the M-24 Combat Tank

Automatic gear operation in reverse is a new development for the M-24. According to Army men this enables the M-24 to rush up to the crest of a ridge, fire at an enemy objective, back immediately away, reload and zig-zag up to a new firing position so that enemy artillery trained on the original firing position cannot knock the tank out of its reappearance.

The welding of the armor plate hull presented a formidable problem because surfaces are all designed to slant at angles so that bullets cannot hit the tank squarely. Special fixtures were designed to hold the tank body to close tolerances and specialized technique required that the unit be kept at a constant temperature throughout the welding process. From long years of experience since pioneering in the welding of truck bodies and hoists and transport tanks, one company has acquired the "know how" that has established its reputation as one of the foremost welding plants in the country.

* The Heil Co., Milwaukee, Wis.

Side View of the M-24 Combat Tank

Maneuverability of this new 20-ton weapon, which has been made 1 ft. wider than the heavier medium tank, is further improved by very wide trackage and reduced ground pressure now lower than the tread of a man of average weight. Tests at Army proving grounds show that it can climb up anything it can cling to, which means inclines up to 60%, and that it can surmount a vertical obstacle 36 in. high with ease. Ordnance officials say that this soft "footing" ideally adapts the M-24 to the marshy areas of the current Pacific theater of war and to the off-summer seasonal conditions generally prevalent in Europe. Suggestive of the side sweeps being made by Gen. Patton's command in France, the M-24 will operate well over 100 miles without refueling.

In addition to its 75-mm. new high-velocity cannon, it carries a 50-calibre anti-aircraft gun, smoke mortar, 30-calibre coaxial gun and a 30-calibre bow machine gun swivelled to spray over a wide frontal arc. It carries additionally, sub-machine guns for each crew member as well as a supply of grenades.

Recognizing the possible far range of tanks in modern combat, the M-24 achieves a new high in crew comfort in this type of vehicle, exceeding the riding ease of practically all other types of military vehicles. The drivers ride on adjustable seats, and there is controlled ventilation all around. Suspension is of the torsional bar type with shock absorbers and compensated idler.

This full-tracked fast, light tank carries a crew of five—commander, driver, gunner, loader and assistant driver. Normal cargo includes more than 4000 rounds of ammunition. Dual controls enable the assistant driver to take over in an emergency. The design of the M-24 places the driving compartment up front, the fighting compartment in the center and the engine compartment in the rear. The turret in the M-24 is a full 5 ft. in diameter, with a continuous ball bearing mounting and a 360° traverse. The turret mounts the 75-mm. cannon and the coaxial machine gun.

Steering is remarkably easy for this type of weapon, say Army technicians, despite the 16-in. wide tracks of steel blocks, 74 blocks to a side, running on ten demountable rubber-tired suspension wheels coupled to airplane-type hydraulic shock absorbers.

The vehicle has a width of 112 in., height from ground to turret top of $86^{5}/_{8}$ in. and over-all length of 216 in., including the overhang of the cannon.

To simplify the supply problem on foreign battle fronts, the tank was designed to utilize wherever possible parts and service facilities, also cannon to other Allied combat weapons.

This simplification of supply parts also extends in the M-24 to interchangeable right- and left-hand engines and other units in the Cadillac "power train."

The multitude of suggestions and refinements in the M-24 which came from "GI Joe" include the placing of first-aid kits outside the chassis. "Joe" asked that this be done not only to conserve space inside, but, he explained, he was like a motorist in a traffic accident in that he was usually outside the vehicle before he was conscious of whether he needed a first-aid kit.

Fabrication of Engine Exhaust for EC-2 Cargo Vessels

THE fabrication of engine exhausts for cargo vessels represents a series of ingenious factory procedures by the Weber Showcase & Fixture Co. of Los Angeles that have been combined to reduce cost of manufacture and short-cut production time.

First a sheet of $^{3}/_{8}$-in. steel plate, 9 x 6 ft., is cut to a pattern which will fit one shape of the elbow to be formed. The sheet, after having been torch cut, weighs approximately 300 lb.

One at a time these pieces are swung into a blast furnace at a temperature of 1400° F. and are heated for 15 min. after which they are removed and placed on the face of a female die of a hydraulic press nearby. Under 400 tons pressure they are pressed into elbow halves. The rough shell which represents one-half of the elbow is taken to a cutting table where a portable radiograph cutting torch travels in a circular track around the curved edges of both sides of the metal, and the piece is trimmed down to the correct dimensions. After the actual trimming of the metal has been completed, the torch makes another complete trip and mitres the edges for welding the two halves together.

Data and photo courtesy the Hobart Brothers Co., Troy, Ohio.

Joining the two halves is done with arc welding, but the method used to clamp and draw the edges to be welded into position is somewhat unusual. After preliminary tacking of the two halves together, two small brackets are welded on either side of the seam and a push-pull, screw type jack is fastened on these brackets and the seam drawn into a snug position where it is firmly held until the welding is completed.

Two welding necks are installed at each end and the 25-in. diameter welded elbow is completed and ready for installation in EC-2 Cargo Ships.

Some Applications of Welded Aircraft Tubing*

By J. S. Adelson† and Park Hill‡

TUBING is one of the major steel products used in aircraft construction and although many diversified parts of the plane are made of tubing this discussion will deal particularly with applications of welded tubing in the power plant. Welded tubing has made tremendous strides over the past 20 yr. Developed originally as a light gage mechanical tube with a wall thickness of about $^1/_{16}$ in. or less for such uses as bedsteads and automobile exhaust pipes, its use was gradually expanded until there is practically no field of use for tubing where welded tube has not been given approval. In achieving this acceptance, welded tube has been put through extensive tests and trial installations and has proved its efficiency and durability beyond any question in the mind of the user. The outstanding example is the millions of feet of boiler tubing now in use.

The method of manufacture is essentially simple. The raw material, which is flat-rolled stock sheared to very accurate width, is formed cold into a butted tube and the edges butt welded by a continuous process. Obviously, there are several major advantages to a tube made in such a manner since the surface both inside and outside is that of a rolled product and therefore free from defects. (The tubing can be examined internally prior to welding by inspection of inside surface while in strip form.) As a general rule, no further operations are necessary except for the standard finishing operations, such as straightening, cutting to length, inspection, etc., unless special tolerances or especially high physical properties are required, in which event the tube is given a cold draw pass to obtain these properties.

With the tremendous increase in requirements for tubing upon our entry into the war, it was necessary to develop new sources of supply for tubing. The logical source for such tubing was the welded tube plants because production could be increased tremendously with relatively little increase in existing equipment.

This paper will deal with three types of tubing; namely, alloy 4130 and 8630 tubing for motor mounts, low-carbon tubing for intake tubes, and stainless tubing for exhaust stacks. Welded stainless tubes had been accepted long ago by the Navy, and there was no problem involved in producing this product immediately. Alloy tubing, however, presented a much more difficult problem. Experiments had been conducted over a period of years leading to development of the proper welding technique to manufacture this type of tubing. Republic Steel Corp., Steel and Tubes Division, developed the correct welding procedure to produce a welded tube with properties equivalent to that of the base metal. A series of tests were then conducted in our own laboratories to determine whether our product conformed to the requirements of the War Department, Navy Department and Department of Commerce. Upon completion of these tests, samples were submitted to various government agencies as well as a number of consumers, and their findings confirmed our conclusions that the welded tube was satisfactory for the application. As a further improvement in welding technique, we have developed an electric nondestructive method of testing to which every foot of tubing is subjected. Based upon these tests, welded tubing was accepted by all the interested agencies and the necessary specifications were written to cover the product, each specification having the requirement that the tube be subjected to a nondestructive test.

Engine Mounts

The importance of engine mounts is clearly defined in the following paragraph abstracted from one of the Glenn L. Martin Engineering Lectures prepared by John J. Buckley:

"Foremost among the primary structures of an airplane is the engine mount, a highly stressed unit that requires great care in both design and construction to assure safe transmission of the thrust applied by modern radial engines to the wing. The mount must withstand not only the tremendous loads of tension, compression and torque generated by the powerful engine units, but in addition, it must be designed to provide for shock loads caused by landing, with the weight of the engine supported far forward of the leading edge of the wing."

Welded tubing is used extensively for this application either in the X-4130 or 8630 analysis. The tubing is made from cold-rolled steel which had been annealed because experience has proved that the softer the raw material, the simpler the welding technique. Weldability is also improved by heat treatment prior to the final normalizing operation. After welding, all tubes are normalized at about 1650–1700° F. and this accomplishes a twofold purpose. This heat treatment results in complete recrystallization of the weld area making it uniform with the rest of the tubing, and in addition, results in

Fig. 1—Air Intake Tube on Large Motor

* Paper delivered before annual meeting of American Society of Mechanical Engineers in New York City on Dec. 1, 1944.

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physical properties which conform to the requirements of the various applicable specifications, which are 75,000 psi. minimum yield point and 95,000 psi. minimum tensile strength. After normalizing, the tubing is then given a tempering or stress-relieving operation at about 800–1000° F., depending upon the size and chemistry of the individual heat. The normalizing operation is done in a continuous controlled-atmosphere furnace so that no scale is raised on the tube and the original cold-rolled surface of the raw material is retained. The tempering or blueing operation is also accomplished in the continuous furnace immediately following the normalizing section. There is no scale except for a very thin blue oxide coating which is hardly measurable and does not interfere with any subsequent assembly operations. The tempering operation also accomplishes a twofold purpose: it relieves any internal stresses resulting from the normalizing treatment and further increases the yield point and may even result in increased ductility.

After heat treatment, the tubing is straightened, given the electric nondestructive test, checked in the laboratory to insure conformance to physical requirements, oiled and cut to the proper length.

The first operation in the assembly of the motor mount is the forming of the ring. This is done cold in a rolling machine which insures accurate dimensions in contour. The ring is then completed by welding the open ends. This welding operation and subsequent welding operations may be either arc or acetylene. General practice is to use a low-carbon rod as filler metal since it has been found that sufficient alloy is picked up from the tubing in the welding operation to assure ample strength in the joint. The second operation is to weld the lugs, which are usually steel forgings, to the ring. Since these must be accurately aligned the ring is straightened after the lugs are welded to it. Heat treatment to relieve stresses may be applied during various steps of the assembly to insure freedom from stresses which might result in cracks. Mr. Buckley says:

"Although finished assemblies are held to close dimensions, it is impossible to keep them to the tolerances required by the specifications without some machining. Through the use of the fixtures and machinery described below, however, dimensions can be held to tolerances as close as ±0.005 of an inch. These machining operations consist of drilling, reaming, counterboring and countersinking. All of the machining operations on the finished mount are performed by a Radial Drill which requires two special fixtures."

Fig. 2—Air Intake Tube Presenting an Extremely Difficult Fabricating Problem

Fig. 3—Stainless Exhaust Header after Bending, Sizing and Facing

The completed unit is subjected to Magnaflux inspection for the location of cracks, laps, seams, inclusions and other welding defects. This operation is applied primarily as a check on the assembly welding operations since the tubing has already been checked for quality by the much more sensitive tube testing equipment.

Aircraft Intake Tubes

Due to the severity of fabrication operations, close tolerances, physical requirements of the finished parts and rigid inspection, the production of aircraft engine intake tubes presents a very difficult problem to both the tube manufacturer and the fabricator.

The tubing is made from low-carbon steel to Aeronautical Material Specification 5053.

To successfully meet the requirements, the tubing must have all these characteristics:

1. Sound homogeneous steel free from laminations, seams, blisters, jiggers, scale marks, etc.
2. Maximum ductility.
3. Freedom on both the inside and outside from minor manufacturing defects such as scratches, mandrel marks, shears, waves, dents, etc.
4. Absolutely clean. (This refers to steel particles and abrasives of all kinds as well as rusts and oxides.)
5. Ability to stand considerable reduction of area without splitting, cracking or opening up minor surface imperfections.
6. Close size and wall thickness tolerances.

The problem as to whether these requirements could be met in a relatively large diameter, light wall tube ($2^{3}/_{8}$ to $2^{9}/_{16}$ in. x 20 gage) offered a real challenge to the welded tube manufacturers when it was presented to them in the early days of the war. Little tubing requiring all these characteristics had ever been produced in commercial quantities which meant there was little or no history or experience to draw on.

Starting with specially selected and closely controlled, cold-rolled steel, it was found that many operations were required to produce satisfactory tubing. Four of these operations, i.e., welding, heat treating, straightening and nondestructive electric testing were found to require special equipment and supervision. Furthermore, the idea of absolute cleanliness required a general educational campaign.

Some of the problems involved are: Bending tubing $2^{9}/_{16}$ in. O.D. x 0.035 in. wall thickness up to 90° on center line radii as small as $3^{1}/_{4}$ in. Multiple bends, flaring, flanging, expanding, etc., to tolerances 50% closer than commercial practice in the industry previously. Making short radius bends with practically no reduction of the in-

side diameter in the bend area and freedom from wrinkles, waves, scratches and minor fabricating marks and impressions. On some of these parts, it is impossible to locate from either end of the tube after the first operation. Therefore, the first bend must be made to almost zero tolerances and all subsequent locating is from this point.

To prevent rust between operations the parts must be oiled, and in ordinary atmospheres enough dust and grit will accumulate to prevent further fabrication without cleaning. On the more severe mandrel bending operations a very heavy lubricating medium is required and means had to be developed to keep this medium free from steel particles, grit and other abrasive agents.

If the inside diameter and wall thickness of the tube could be held to a dimensional tolerance of 0.001 in. or if the fabricator could segregate the tubes into lots having these dimensional tolerances and build a complete set of tools for each lot, the mandrel bending operation would be relatively simple. Either of these possibilities are, of course, commercially impractical and a satisfactory solution has been largely due to the ingenious tooling on the part of the fabricator plus unusual quality control on the part of the tube manufacturer.

Tooling for other operations, such as flanging, flaring, beading, expanding, spacing, indenting, chamfering, etc., has required either new art or tools made to tolerances prevously unheard of in tube fabricating work.

Aircraft Exhaust Header

This aircraft exhaust header, which is a $2^1/_2$-in. O.D. x 0.049-in. wall thickness tube made of 18–8 stabilized stainless, has proved to be another difficult fabricating job. After several years, its production is still limited to one tube producer, one fabricating subcontractor and one prime contractor.

Length of the part before flanging is 10.90 in. + 0.031 in. − 0.000 in. face plate measurement. This means that any variation in degree of perpendicularity of the faces is included in the length tolerance. There are two bends in close proximity on a 4.219-in. center line radius. The distance of straight tube on the short end is only 0.668 in. The tolerance on the O.D. of the ends is ±0.005 in.

These extremely close limits give some indication of the difficulties the fabricating subcontractor was faced with. Special automatic hydraulically operated equipment had to be designed and built for the sizing and facing operations. On the two mandrel bends it was found that standard hydraulic benders could be used with specially designed tools. The dies, mandrels, wiper blocks, following blocks, etc., were designed to maintain full cross-sectional area in the bends. Normally this can be accomplished by a conventional balling operation after the bends. By this we mean pushing a series of hardened balls through the part while it is held in the die.

However, due to the tendency of stainless steel to gall and the requirement of freedom from internal marks or surface defects, it was decided to attempt to maintain the required sectional area on the benders. After design of several sets of experimental tools, this was accomplished.

Bearing pressures in the hydraulic bender were found to be above anything previously encountered and had to be compensated for.

Again elimination of all steel particles, minute cutting burrs and grit and abrasives of all kinds became of paramount importance.

It was found that even though the chemistry, physical properties, wall thickness and size tolerances of the tubing were closely controlled by the tube producers, there was enough variation from one lot to another—a lot being that part of one heat, welded, heat treated, etc., at one time—that each lot has to be kept separate through all fabricating operations and specially adjusted for on six of the operations.

In the prime contractor's plant, the finishing operations, such as the welding on of fittings and collars, flanging, etc., are of a somewhat conventional nature, but due to dimensional and visual requirements, they are extremely difficult and require familiarity with the best stainless practices.

From the production of the cold-rolled, stainless steel to the final operation on the fabricated part, consideration has to be given to the elimination of all minor defects, normally not considered harmful in tubular products.

This part is the primary unit in removing exhaust gases from a very large aircraft motor and "hot spots must be guarded against regardless of costs."

Aside from the fact that this history is another example of how American Industry has met and overcome obstacles to War Production, it points to something that is far more important for the future. These developments have meant progress in the refinement of tube fabricating techniques that were unheard of before the War—and these new techniques mean that anyone requiring a precisely fabricated tubular part in the future will find it much less difficult to get what he wants.

1945 A.W.S. Directory

In order to conserve paper the new 1945 A.W.S. Membership Directory, now available, will be only sent to those requesting a copy. There is no charge to members of the Society. Address request to:

American Welding Society
33 West 39th Street, New York 18, N. Y.

THE AMERICAN WELDING SOCIETY

ACTIVITIES – RELATED EVENTS

ANNUAL MEETING, AMERICAN BUREAU OF SHIPPING

The 83rd annual meeting of the Board of Managers and Members of the American Bureau of Shipping was held February 6, 1945, in the Bureau's Board room, 47 Beaver St., New York City.

President J. Lewis Luckenbach presided and expressed his gratitude to more than 60 managers and members for their attendance.

Mr. Luckenbach was elected President for the thirteenth time, and the following were re-elected: David Arnott, Vice-President—Chief Surveyor; Joseph W. Powell and William D. Winter, Honorary Vice-Presidents; Jerome B. Crowley, Treasurer; John W. Cantillion, Secretary and Assistant Treasurer; and Kenneth D. Hull, Assistant Treasurer.

The following were elected to the Board of Managers:

For the three-year term expiring January 1948: Fraser A. Bailey, Thomas E. Buchanan, Robert Haig, Richmond K. Kelly, Lynn H. Korndorff, John McAuliffe, John F. Purcell, Owen C. Torrey, Harry W. Warley, William D. Winter.

For the two-year term expiring January 1947: Harold Jackson, Joseph A. Moore.

For the one-year term expiring January 1946: John M. Griser, Daniel K. Ludwig.

The following were elected to the membership of the American Bureau of Shipping: John M. Griser, President, Alabama Dry Dock & Shipbuilding Co.; W. Miller Laughton, Manager, Bethlehem Yards, San Francisco, Calif.; Emmet G. McKeever, President, Pan-American Petroleum & Transport Co.; Owen C. Torrey, President, Marine Office of America; John Byrne, President, Universal Insurance Co.; J. S. Gilbertson, Marine Secretary, Hartford Fire Insurance Co.

In his remarks, Mr. Luckenbach said:

"Production of large merchant types of steel seagoing tonnage over 2000 gross tons in 1944 for the Maritime Commission and private interests again, as in 1943, reached unheard of totals, aggregating 1463 vessels of 11,403,163 gross tons and 16,143,065 deadweight tons. Great as this achievement is, it did not quite measure up to the record-breaking year of 1943, when there were produced 198 more vessels than in 1944 and about 1,000,000 gross tons and 2,300,000 deadweight tons more. However, merchant ship completions averaged four every day in 1944, and three and one-half per day since we entered the war. The record construction rate of merchant vessels achieved during 1943 would have been duplicated in 1944 were it not for the curbing of overtime labor and the transition from Liberty ship building to Victory ship construction. However, American shipyards in 1944 did have a record year from a production standpoint, as in addition to merchant ship construction, 39,971 units, mostly landing craft, were completed for the Navy, and hundreds of small vessels for the Army, Coast Guard and the Defense Plant Corporation.

"The vessels produced in 1944 were constructed by 38 of our major shipyards, two of the yards finishing more than 100 ships each—actually one every three days. A number of our older established shipyards are still engaged exclusively upon naval construction and did not contribute to the large volume of merchant shipbuilding.

"Having in mind that there existed throughout the world in September 1939, a total of 9278 merchant vessels of 52,700,000 gross tons and 72,800,000 deadweight tons, 27% of which was over 20 years of age, the shipbuilding achievements of the United States since that time stand out as one of the most remarkable developments of the war. In that comparatively short span of time we have produced a new merchant fleet nearly the equal of the prewar world tonnage from a performance and operation standpoint, totaling 4009 units of 30,576,606 gross tons and 44,442,165 deadweight tons. There will be added to this total by the end of 1945 approximately 1200 vessels of about 9,300,000 gross tons and 13,000,000 deadweight tons. With prewar world tonnage reduced 30 to 50% due to war losses, it can be readily seen that the United States controls the medium of transportation by sea. We have already created a fleet four times larger than existed under the American flag in 1939 and by the end of 1945 it will be five times larger. This has all been accomplished under the very able direction of the Maritime Commission.

"Of the total of 1463 merchant vessels constructed in 1944, 1223 were of the cargo or combination passenger and cargo types, representing 8,916,766 gross tons and 12,188,108 deadweight tons. While a majority of the vessels in this category were Liberty emergency cargo ships, totaling 722 with a deadweight tonnage of 7,679,113 tons, Victory ships also came into production during the year in shipyards which had completed their Liberty ship contracts. A total of 209 vessels of the Victory design were completed, having a deadweight tonnage of about 2,000,000 tons. This type of vessel is now being built by six shipyards, and some have been constructed in 59 days.

"The Liberty ship building program is nearing completion, with 148 still scheduled as of January 1st—24 of which are being completed as colliers. A total of 2504 Liberty ships have been completed in an average time of 62 days each and 6[illegible] Liberty ships were completed as tankers. Several shipyards have completed their Liberty ships contracts with average building times of 41 to 45 days. These ships are now being built only on the Atlantic and Gulf Coasts, as the Pacific Coast programs were completed.

"Many of the C1-A, C1-B, C2, C3, C[illegible] and P2 basic design types of vessels were completed during the year, together with the first of new C1-M design Diesel propelled cargo ships. Except for two small lighters, the concrete shipbuilding program has been completed; also the wooden barge program.

"A new record for tank ship production was established in 1944, when 240 vessels of 2,486,397 gross tons and 3,954,957 deadweight tons were completed. This is 500,000 deadweight tons more than were finished in 1943. Seven shipyards produced these 240 tankers, the Sun Co. completing 69, the Kaiser Swan Island yard 64, and 44 each by the Marinship Corporation and the Alabama Dry Dock & Shipbuilding Co. Turbo-electric propulsion machinery was employed in 221 of these new tankers, totaling 1,688,360 hp. Also completed in 1944 was one of the largest bulk tankers in the world—the "Phoenix" of over 22,000 deadweight tons. Five additional sister ships will be constructed.

"Since the start of the war in Europe in September 1939, American shipyards have, in answer to the loss in tankers by German submarines, produced 579 new tankers of 5,711,884 gross tons and 9,085,939 deadweight tons, with propelling machinery totaling 4,142,620 hp. The record building of tankers has more than made up Allied losses due to sinkings and puts the United States in a dominant position so far as tonnage of this type is concerned. In September 1939 there existed throughout the world 1507 tankers of 16,008,200 deadweight tons, with 1033 of these vessels flying the flag of the United States, Great Britain and Norway. Losses by the two latter nations of this type of vessel have been particularly severe. With 238 tankers still under contract to be constructed, the United States should control by the end of the year close to 1000 tank ships of about 13,000,000 deadweight tons—a fleet about equal to the entire prewar world fleet because of a 25% increase in speed in the new vessels.

"The shipbuilding industry of the United States established a new record in 1944 by installing in merchant vessels a greater horsepower than was ever produced in one year. The main contributing reason for this new achievement was the transition from Liberty to Victory ship-

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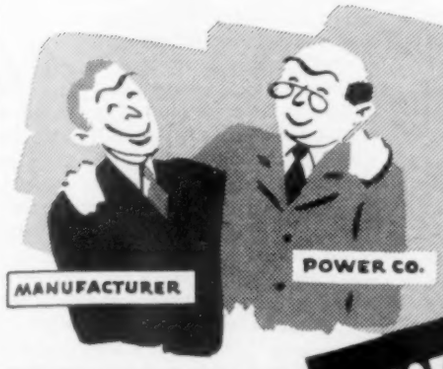


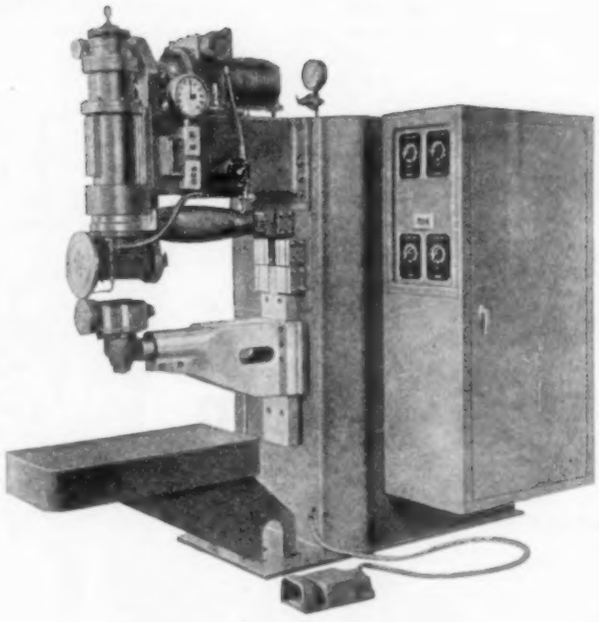
"THREE-PHASE"

Manufacturers and power companies have long been at odds over the problem of supplying power for heavy reactive loads. Particularly in the case of heavy duty resistance welding of steel, power suppliers have often found it necessary to place a ***demand charge*** on the manufacturer.

One reason for this is that conventional welders must utilize the comparatively high frequency alternating current in their secondary circuit. High frequencies mean high reactance, with resultant operation at very low power factor — often 25% or less. Low power factor means more current must be available to meet the same demand . . . often requiring a boost in the size of distribution facilities.

Sciaky "THREE-PHASE" welders are designed to overcome this, as well as other difficulties encountered in heavy duty resistance welding. An ideal low frequency current is produced at the electrode tips by an ingenious system of first, rectifying all three phases of the supply to d.c., then reconverting to an alternating impulse. Operation is on a ***balanced three phase load*** at ***near unity power factor.***

Bulletin 204-A describing fully the Sciaky "THREE-PHASE" principle will be gladly sent on request.



The Sciaky THREE-PHASE principle has been effectively applied to heavy gauge seam welding. The machine illustrated (type PMM.2T-13) welds steel up to two thicknesses of .109" and can achieve a speed of 84" per minute on two thicknesses of .040". Transformer rating is 120 KVA at 50% duty cycle. Unit is entirely self-contained with hinged side mounted rectifier and control cabinets. Electronic controls provide adjustable on-off time, squeeze and hold time.

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building, involving three times greater horsepower per vessel. A total of 7,448,950 hp. of main propelling machinery was installed in 1463 seagoing merchant ships. This total horsepower is almost twice as great as existed in the entire American merchant marine prior to our entrance into the war in 1941. Propelling machinery installed in merchant ships in 1944 was composed of the following types and total horsepower:

	No. of Ships	Total Hp.
Geared turbine	426	3,546,740
Turbo-electric	254	1,947,860
Reciprocating	727	1,817,500
Diesel	56	136,850
Total	1463	7,448,950

"A significant feature of the wartime shipbuilding program in the United States has been the utilization of internal combustion engines on a vast and unprecedented scale for the propulsion of many varied types of small vessels. An indication of the extent of this trend is to be had in the fact that the United States Navy had in operation at the end of 1944 approximately 32,000,000 hp. of Diesel engines. This total horsepower of Diesel propelling machinery is more than seven times greater than the total horsepower of all types of propulsion machinery employed in the prewar seagoing merchant marine of the United States, which had only 300,000 hp. of Diesel engines. While, of course, these naval units were mainly special types of landing vessels, a number of larger installations do exist. The manufacturing of Diesel engines in this country is now on a far greater plane than probably existed before the war in all European nations, the greatest exponents of this type of machinery for seagoing vessels. Many varied types of Diesels are now available in the United States and the horsepower of the individual unit is being increased as a result of experience, while the weight per horsepower is being decreased. However, where larger horsepowers are concerned, steam greatly predominates.

"During 1944 a total of 136,850 brake hp. of Diesel engines was installed in 58 new seagoing merchant vessels. This is the greatest amount of Diesel propulsion machinery ever built and installed in the span of one year for merchant ships of the United States. It is equal in power to one-half of the American flag prewar Diesel-propelled seagoing merchant vessels. Nineteen of the standard C1-A type Diesel-propelled cargoships were completed during the year, together with 39 of the smaller C1-M design. Of the latter type there are now on order 231 additional vessels requiring a total of 392,700 hp.

"As in 1942 and 1943, Pacific Coast shipyards completed the greatest number and tonnage of merchant vessels, finishing 576 with a gross tonnage of 4,579,689 tons. Atlantic Coast yards delivered 572 ships of 4,554,601 gross tons, while on the Gulf 287 vessels of 2,162,333 gross tons were turned out. Great Lakes yards finished, in addition to numerous smaller vessels, 24 merchant ships of 106,540 gross tons. For the third successive year the State of California led the country in producing merchant vessels, turning out 409 vessels, or almost one-third of the total completed in the United States. The State of Maryland was second with 145 vessels.

"The structural troubles of some of our welded ships is still a matter of concern, although the general picture is somewhat brighter than at this time last year. The failures experienced in service vary in degree from minor cracks which can be readily repaired and which are no more serious than a few leaky rivets to extensive plate fractures which propagate suddenly and which may result in a dangerous loss of strength to the entire structure. That no serious failures occurred last year in the period between April 1st to November 1st is not surprising as it is under the heavy weather and low-temperature conditions associated with the winter season that such troubles would naturally be expected. Some welded ships seem to have critical spots from which fractures start for no obvious reason and from a source which would normally be considered of no great significance. Experience and expediency have dictated the use of the more flexible riveted attachment in longitudinal seams and gunwale connections in order to provide barriers against crack propagation in those particular types of vessels which experience has shown to be particularly susceptible to trouble. The corrective measures undertaken along these lines on our

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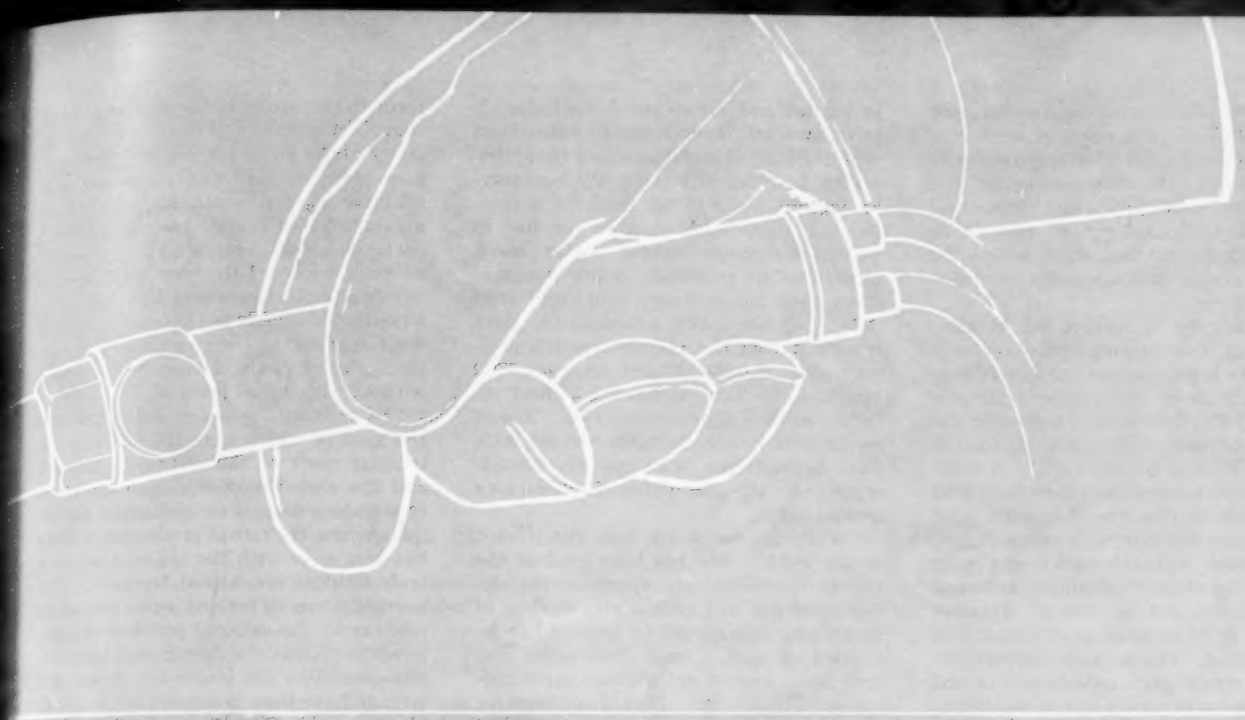

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later Liberty ships during construction and being applied to such ships in service as rapidly as opportunity affords appear to be quite effective. In this connection the comparative immunity from structural troubles as evidenced by our records on those particular welded ships where the longitudinal side shell seams are riveted is worthy of note.

"With a view to solving our welding problems an enormous amount of research work is now in progress at various laboratories throughout the country largely financed by the Government and under the control of Advisory Committees on most of which the Bureau is represented. A number of Committee meetings have been held at this office so that the Technical Staff is thoroughly familiar with these important activities. Valuable work is also being done by some of our shipbuilders and steel manufacturers and it would certainly appear as if every avenue of research is being explored. The projects comprise the taking of strain gage measurements and the evaluation of stress in the subassemblies and completed assemblies of welded ships, also on ships in service. A number of investigations into the behavior of the steel itself under varying conditions of stress and temperature have been initiated in an endeavor to solve the problem of brittle crack propagation in the comparatively rigid welded structure. Fundamental investigations of this character progress step by step, one project usually leading to another, and such work cannot be unduly rushed if the danger of drawing premature and unwarranted conclusions is to be avoided. Investigations carried out with the limited facilities in our own laboratory, together with our analysis of service failures, point to the need for a commercial steel more suitable for use in welded structures having higher notch impact values especially at low temperatures than the ordinary structural steel now available. The accumulative data resulting from the various research projects when correlated and analyzed will undoubtedly have a beneficial effect on future welded ship construction. Sound workmanship and suitable design will, however, continue to be essential considerations for the production of satisfactory welded ships.

"While the transition from the riveted to the welded ship has been gradual the change has been accelerated by the demands of war and such a new method of construction could not be expected to be applied on such a huge scale under war emergency conditions without experiencing some difficulties. Had it not been for the change to this type of construction it is doubtful if half the number of ships shown in this report could have been delivered, and even half of those kept in continuous operation considering the additional drydocking time which would have been necessary for the re-driving of thousands of rivets if the experience with the riveted ships built during the last war is any criterion. The making of a riveter requires months, whereas a welder can be made in relatively short time. Besides, a riveter through the nature of his work must be of rugged physique. Women are used in many of the yards for welding. Few women could be used as riveters and with selective service which has required so many men for the armed services, if riveters had been taken out after their training, as welders have, I shudder to think what our ship production would have been. As a matter of fact, the welded ship has shown itself superior to the riveted ship in sustaining much of the damage of war action without widespread leakage.

"In spite of the many difficulties, not the least of which were the necessity for training most of the shipyard personnel and the varied modifications required to fit standard designs to specialized war requirements, the rate of production of ships has kept pace with the urgent need on a scale hitherto considered fantastic. The acute shortage of trained personnel and its relation to the national problem of manpower requirements during such emergencies constitute an important lesson and seem to have been impressed in the minds of all our people. However, it is vitally necessary to see that the facts are remembered during peacetimes; that is, that continued training and employment be stressed so that we can maintain a sufficient merchant marine to guarantee our national security and defense if a similar occasion should again arise.

"While there has been a marked simplification of design details because of the use of welding and a considerable progress in shipbuilding methods through an extended

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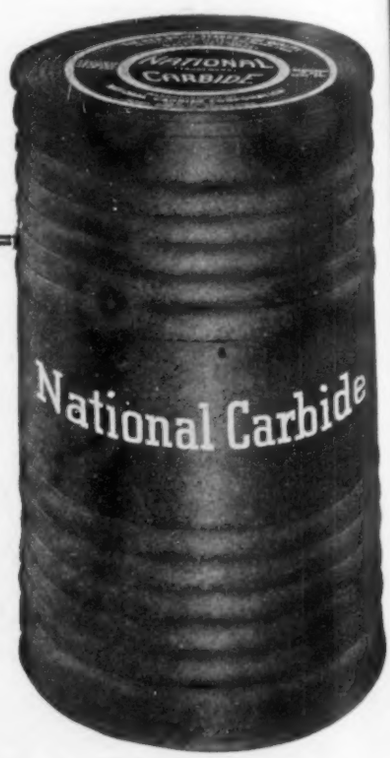

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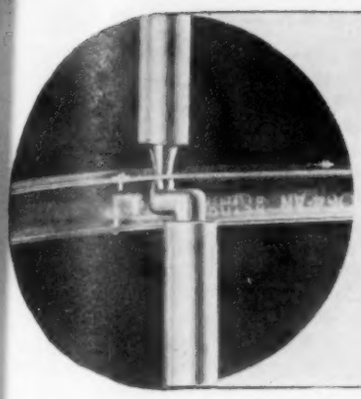

DO'S *and* DON'TS
for
Resistance Welding Machines and Operations

Do's

1. Clean and tighten all electrical connections in the secondary circuit regularly.
2. Protect welding transformer slides, bearings and other parts from flash particles.
3. Keep the welder throat area to the minimum permissible dimensions.
4. Design welding fixtures and clamps with non-magnetic materials whenever possible.
5. Lubricate the resistance welding machine, motor, gears and slides at periodic intervals.
6. Clean all air or oil filters regularly.
7. Keep leather cup washers in air cylinders soft and pliable with light motor oil.
8. Calibrate all pressure applying mechanisms so that the exact welding pressure is always known.
9. Use proper capacity welding machine for the job.
10. Adjust the welding machine properly with the current initiating devices so that the current cycle is spaced midway in the pressure cycle.
11. Clean either chemically or mechanically all material to be welded that has dirty, scaly, oxidized or otherwise contaminated surfaces.
12. Provide suitable fixtures for holding the work in position prior to applying electrodes.
13. Provide rigidity in the welder arms and holders to prevent skidding of the electrodes, wheels or dies under pressure.

Don'ts

1. Don't permit flash particles to accumulate on the welding transformer.
2. Never use poorly maintained resistance welding equipment.
3. Do not use a long welder arm extension or a wide arm separation unless the parts to be welded necessitate it.
4. Avoid placing or fastening steel parts or fixtures in the throat area of the welding machine.
5. Shun lubricants which are not recommended by the welder manufacturer.
6. Don't use air operated machines when the oil bowl in the air line is empty.
7. Never permit oil or grease to come in contact with the transformer winding, electrical wires, or connections.
8. Never permit sliding pressure members to become too tight or jammed, since this will increase the frictional forces and inertia of the moving members.
9. Avoid using a low capacity welder for heavy welding jobs.
10. Do not allow welding current to be applied before full pressure is on work, or permit pressure release before the welding current is cut off.
11. Never weld unclean metals, scaly stock, or metals with poor surface condition.
12. Don't use welding tips, wheels or dies to form or shape parts in the welder.
13. Never apply the electrodes to the work with a hard impact or hammer blow.

DO increase production by using Mallory Standard Resistance Welding Electrodes —spot welding tips and holders. Consult us for seam welding wheels, flash, butt and projection welding dies for your particular application. Write for your copy of the electrode catalog and the Mallory Resistance Welding Data Book sent gratis to resistance welding engineers when requested on company letterhead.

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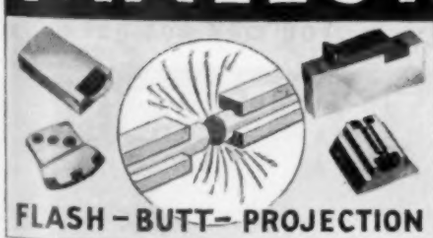

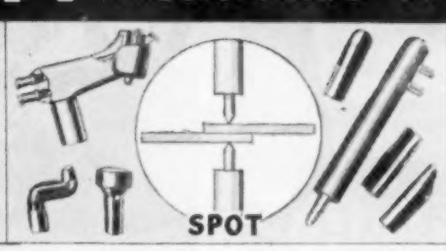

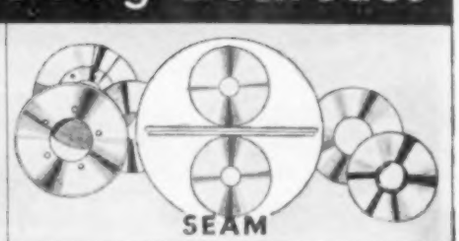

use of fabrication methods, the fact that so many ships were built of the same design in different types might prompt the wrong conclusion regarding developments in naval architecture. In marine engineering, necessity has demanded the use of types of machinery which could be most readily manufactured. It has also required the use of alternative materials. Until experience in the use of the alternative materials has been gained, no accurate judgment can be placed on them. Expediency has not permitted much in the way of development of the large internal combustion engine. However, tremendous development of this type of machinery in single units up to about 2000 hp. has been the outgrowth. Geared turbine and turbo-electric, together with some reciprocating engines of varying types, have been called in to play a part and developments in higher steam pressures and gas turbines may be looked for. Such experimental and research work has been done and until these are brought out into the light after the war it would be difficult to predict what we might expect. However, it is safe to say that substantial strides will be made both in material and construction which will be beneficial to the design, navigation and operation of ships.

"Progress may also be expected in co-operation with other nationals in the studies emanating under the auspices of the Coast Guard on the rules governing safety of life at sea, admeasurement and other maritime problems, in order that our ideas and regulations and those of foreign nationals be coordinated.

"The Maritime Commission started out with what seemed to be an ambitious program. The war augmented this program literally hundreds of times. The Commission called for the complete co-operation of the shipbuilding industry and many facilities hitherto unthought of for use in maritime production were utilized, all of which added up and made possible the accomplishment of the preponderous task with which they were confronted.

"Shipbuilding has arisen from a minor industry to second place. The tremendous demand for ships of all types has been perhaps better and more promptly met than any other requirement for this war and the shipbuilding industry and our merchant marine have a right to point with pride to the fact that when the demand was made for the tools with which to win this war, they were not found wanting."

FOUNDRYMEN CANCEL 1945 DETROIT FOUNDRY CONGRESS

Cancellation of the 1945 War Production Foundry Congress of the American Foundrymen's Association, scheduled to be held in Detroit, April 30th to May 4th, was announced recently at a meeting of the Association's Board of Directors, held in Chicago. Although the meeting was to have been devoted exclusively to the presentation of technical papers and reports valuable to the production of castings for war purposes, the society's officers voted adoption of an emergency program to accomplish its aims with minimum use of transportation and hotel facilities.

R.W.M.A. ELECTS '45 PRESIDENT

The Resistance Welder Manufacturers' Association at their January meeting in Detroit have elected Chas. Eisler president of the R.W.M.A. for 1945. Chas. Eisler, owner and director of the Eisler Engineering Co. Newark, N. J., succeeds Floyd E. Taylor, president of Swift Electric Welder Co., Detroit, Mich. Co-vice-presidents are David Sciaky, of Sciaky Brothers in Chicago, and H. V. Beronius, of Welding Machines Manufacturing Co. in Detroit. Chas. Eisler has been building resistance welding equipment for a quarter of a century, this year marking the twenty-fifth anniversary of his organization.

As head of the R.W.M.A. which represents the bulk of the resistance welding industry, Chas. Eisler guides both the organization and its purpose. Among the many activities are improved relations among members, high ethical standards for the industry, encouraging methods for greater economy and efficiency, product improvement, as well as new markets for resistance welding. The result has been many organizational activities and development of specification standards, standard practice and procedure, research and development, cooperation with other associations such as the AMERICAN WELDING SOCIETY, and joint studies with other Industries.

Since the reorganization of R.W.M.A. in 1938, Chas. Eisler has been active in the organization in various capacities—advisory board, public relations committee, arbitration committee; last year he served

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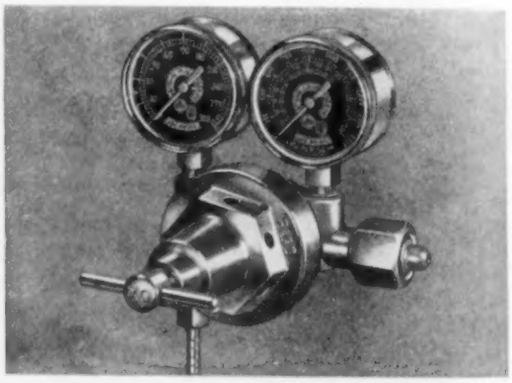

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PAGE *Welding* ELECTRODES

FOR AC OR DC

• We have withheld announcement of this new **PAGE**-*Allegheny* electrode until we put it to every possible test—both in our own laboratories and under actual working conditions with Stainless Steel fabricators.

Now we know it's *right.* It's up to the **PAGE** high standard of quality. This electrode will operate in all positions—will produce smooth beads with very low spatter loss and instant arc action with all types of AC or DC equipment.

Although specializing in Stainless Steel, **PAGE** offers a complete line of welding electrodes. Whatever your needs, it will pay you to . . .

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PAGE STEEL AND WIRE DIVISION
AMERICAN CHAIN & CABLE · BRIDGEPORT

as co-vice-president with W. T. Ober of the Thomson-Gibb Electric Welding Co. of Lynn, Mass.

When the full story of resistance welding is told after the war, this fifty-year-old art will take its heralded place among the many production tools which have helped to make the U. S. the Arsenal of Democracy.

LIEUT. J. C. OWENS AIDS WOUNDED AT TARAWA, KWAJALEIN AND SAIPAN

The job that Lieut. Cuthbert Owens of Beloit is doing in this war is illustrated by his service at Saipan. There, as reported by U. P. and A. P. correspondents, he "as naval doctor in charge of an evacuation and aid station for the wounded, worked for four days straight, with almost no sleep, under constant Japanese fire." He was subsequently awarded the Bronze Star Medal by Admiral C. W. Nimitz for "heroic achievement and outstanding professional ability.

His father, James W. Owens, has since 1935 held the vitally important position of Director of Welding for all Fairbanks-Morse plants. In this and his previous connections, the elder Owens has contributed greatly to the excellence of our country's ships. His honors include a $10,000 first prize in an international welding competition sponsored by the American Society of Mechanical Engineers, the Miller Memorial Medal from the AMERICAN WELDING SOCIETY, and the vice-presidency of the latter organization, which he helped found. He is the author of the textbook "Fundamentals of Welding."

PEORIA OFFICE OF LINCOLN ELECTRIC

Announcement is made by The Lincoln Electric Company, Cleveland, Ohio of a new address for its Peoria Office.

The new office, in charge of L. W. O'Day manager, is now located in larger quarters in the Electrical Building, 214 Second St., Peoria, Ill. Mr. O'Day has been a Lincoln arc-welding engineer for 17 yr. and in the Chicago District. He has been manager at Peoria for 4 yr.

The new facilities, which are located in a building having approximately 25,000 sq. ft. of floor space, provide ample quarters for service, spare parts and engineering and welding demonstrations.

BABCOCK & WILCOX GUN MOUNT WELDING SCHOOL

The nation's supply of vitally needed welders for naval armament has been augmented by 318 men and women who have completed the course and qualified as first class Navy welders at the Welding School of the Rush Street gun mount plant of the Babcock & Wilcox Co. here, it was announced by Cecil H. Gay, Superintendent of the plant, as the School swung into its fifth year. Since its beginning in December 1940, a year before Pearl Harbor, the Welding School has given 85,000 man-hours of instruction and taught welding to 398 students.

The main product of the Rush Street plant is high-caliber Navy gun mounts for dual purpose antiaircraft guns. Among the guns for which it manufacturers mounts is the famous 5-in 38-caliber gun used on nearly every big ship afloat including battleships, destroyers, cruisers and some transports. Known to the men as the "Navy Sweetheart" because of its excellent performance in action, this 5-in. gun has figured in most of the battles in the Pacific. Other guns for which the plant turns out mounts are the 5-in. 25-caliber, dual-purpose gun, the 8-in. 55-caliber gun and the 40-mm. gun used on all naval vessels. The Alliance plant is the only source of mounts for the 5-in. 25-caliber gun outside of the United States Government gun factory.

Intricate Welding Requirements—The type of welding performed at the gun mount shop, Mr. Gay explained, is intricate and vitally important to the strength and durability of the finished gun. Because of the terrific vibration and recoil which the gun mount must bear when the gun is in operation, the welding of the parts must stand up to X-ray examination, and the welding is comparable to that on vessels designed to withstand high pressures. The necessity for enough highly skilled welding labor to meet increasing production demands due to armament ex-

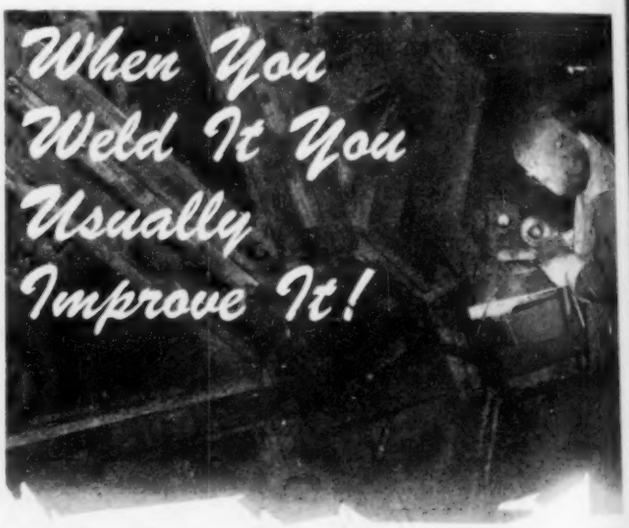
WRITE FOR CATALOG

We manufacture a complete line of resistance spot welders from ¼ to 300 KVA for all types of welding. There is an EISLER WELDER for every purpose.

TRANSFORMERS OF ALL TYPES

WE INVITE CONTRACT SPOT WELDING IN LARGE OR SMALL QUANTITIES.

CHAS. EISLER
EISLER ENGINEERING CO.
779-SO. 13th ST. Near AVON AVE NEWARK, 3 N. J.



This is particularly true of machine tool bases, frames, levers; of diesel engine frames and gear casings; equipment for paper mills; crane and hoist parts; manifolds, blower housings; parts for the great majority of electrical appliances, etc.

Welded construction is almost always stronger, yet lighter—also more sightly and often less costly.

Study your product. Arrange to weld as much of it as possible. Consult United engineers on new plans, or submit present plans for study and estimates.

THE UNITED WELDING CO.
MIDDLETOWN, OHIO
WELDING FABRICATORS OF MODERN DESIGNS

Buy with confidence...

When you specify **"MAJOR"** welding cable, you choose the preferred brand. An independent national survey has voted **"MAJOR"** the first choice extruded type, rubber covered, flexible welding cable—

"MAJOR" Welding Cable extends thanks to the Welding Industry for this recognition.

"MAJOR" WELDING CABLE

SPECIFICATIONS

Size	Amps.	Strands
5	75	950
4	125	1029
3	150	1323
2	200	1666
1	250	2156
1/0	300	2646
2/0	375	3381
3/0	450	4284
4/0	550	5376

WELDING ENGINEERING COMPANY
MILWAUKEE, WISCONSIN
MANUFACTURERS—DISTRIBUTORS
OFFICES AND AGENTS ALL OVER THE UNITED STATES

pansion, led to the establishment of the Welding School at the plant, even before the United States' entry into the war.

EDUCATIONAL PROGRAM FOR RESISTANCE WELDING

In order to broaden the scope of its service to the metal working and fabricating industries, the Resistance Welding Manufacturers' Association has inaugurated a program of cooperative educational activity on resistance welding subject. Recent metal industry surveys have shown that a very large percentage of those firms now using resistance welding in production are planning definitely to do more. The main objective of the educational program will be to encourage and to assist this expanded use by making more widely available a knowledge of the advances in design, in welding techniques and in fabricating procedures which have been made during the war production period.

Essentially this program is a continuation of established activities of the association in sponsoring research projects, cooperating with interested engineering societies and developing equipment standards and recommended practices. In the educational work especial attention will be given to (1) assisting design engineers to improve both product and production by designing component parts specifically for the welding process that is to be used, (2) encourage the use of recommended practices in order to realize maximum economies and consistant good quality from the application of resistance welding, (3) establish the fundamental principles of resistance welding as a basis for proper application of the process, and (4) to interpret research results to design engineers and production executives. Harold S. Card has been appointed educational director in charge of this program, with headquarters in the Citizens Building, Cleveland, Ohio.

BRAZING CONTACTS

Gibson Electric Co., 8362 Frankstown Ave., Pittsburgh 21, Pa., has published a new folder covering Silver-Solder-Backed Contacts in Gibsiloy and Silver for Brazing. The construction and advantages of solder-backed contacts and various methods of brazing are described in detail. Listings and illustrations of standard forms and sizes in which solder-backed contacts can be furnished are shown. Also illustrated are typical assemblies of solder-backed contacts with various types of contact supports commonly used in electrical control apparatus. A table lists the characteristics of various Gibsiloy powder metal contact materials. Copy will be sent free on request. Ask for Catalog C-11.

SAFETY CLOTHES

American Optical Co. announces a new booklet listing and describing AO safety clothing for male welders. Copies of the booklet can be secured without cost by writing the concern at Southbridge, Mass.

Clothing described includes overalls, all-leather pants, hot weather pants, chaps, aprons, coats, cape sleeves and bib, short jacket, sleeves and sleevelets, gloves, mittens and spats.

AO welders' safety clothing, the announcement adds, provides over-all protection against flying sparks, thereby helping to prevent painful skin burns and tending to reduce accident frequency.

Patterns for this safety clothing were developed by an expert designer of men's clothes, working in conjunction with a practical, experienced welder. Sleeves and trouser legs are shaped to fit. Garments are made of as few pieces of leather as possible—no unnecessary piecing out, no useless seams.

DICTIONARY OF ENGINEERING AND MACHINE SHOP TERMS

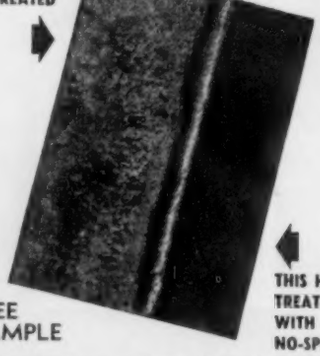
By A. H. Sandy

Compiled in this handy volume are the definitions of many important terms used in machine shops, industries and engineering literature, as gathered by the author during many years of experience both in industry and as a lecturer. Its clear and simple language will make this dictionary useful not only for engineers and students of engineering, but also for foremen and specialized workmen of the various shops and industries. Chemical Publishing Co., Inc., 1234 King St., Brooklyn, N. Y. 153 pages, 1944, $2.75.

for

BETTER WELDING
at
LOWER COST

THIS HALF UNTREATED



NO-SPAT

The Welding Fluid That Is Non-Toxic

FREE SAMPLE

THIS HALF TREATED WITH NO-SPAT

NO-SPAT prevents welding spatter from adhering to metal surfaces — protects metal against rust — saves time and labor costs. Especially valuable in keeping welding jigs clean. Unbiased scientific tests show NO-SPAT maintains maximum welding strength — reduces fumes 30 percent — does not produce carbon monoxide. Extremely inexpensive. No mixing required. No time wasted. Apply and start welding at once. Write for FREE SAMPLE and detailed engineering test Bulletin.

THE MIDLAND PAINT & VARNISH CO.
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For Better and Easier Welding

DUCTONE AC
(E6011 and E6013)
WELDING RODS

Prompt delivery can be made on DUCTONE AC rods, the electrode that has been designed especially for AC welding. This is a premium quality electrode that is far superior to all other AC rods. It is noted for its extra-stabilization in the coating, which makes striking and maintaining an arc easy, and for its all position use . . . Small sizes are especially good for thin sheet metal. Excellent for vertical and overhead welding on DC positive polarity. Extruded all sizes from 1/16" to 1/4" See your dealer.

Territories Available for Distributors

Reach for DUCTONE AC Welding Rods

Chicago Steel and Wire Co.
103rd St. and Torrence Ave.
Chicago 17, Illinois

"Force the Battle," *he says*

LOOK, GENERAL, how manufacturers and builders force their "enemy" competitors to dance to the tune of faster and better Arc Welding.

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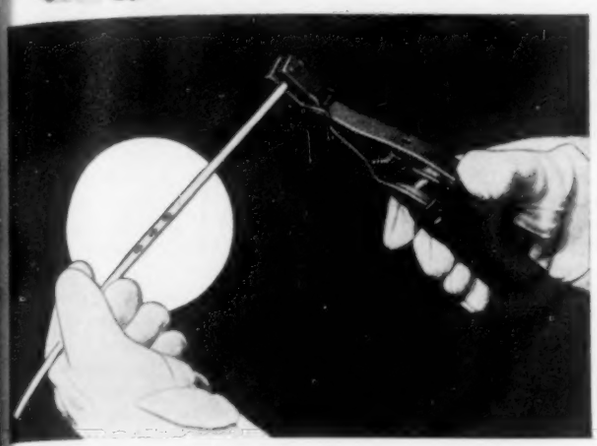
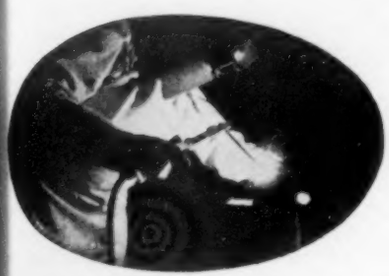


"FLEETWELD"

. . . the world's No. 1 electrode family

THREE DOTS

Enables you to identify at a glance the genuine "Fleetweld"

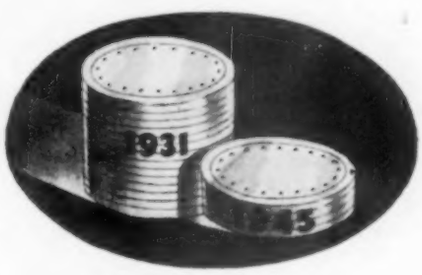


FORCE 1: FASTER and FASTER WELDING

Lincoln Engineers, in constant touch with welding users the world over, provide a fund of ideas for the continuous improvement of "Fleetweld" and the techniques for its use. Result: Deposit rates are faster; spatter and slag loss is less; arc is easier to strike and maintain under all welding conditions and positions.

FORCE 2: HIGHER and HIGHER QUALITY

Every "heat" of wire, every batch of chemicals and every step in "Fleetweld" production is checked carefully by laboratory and production supervisors to make sure that every electrode meets super strict specifications. Continuous refinement of "Fleetweld" has kept it the standard of weld quality the world over.



FORCE 3: LOWER and LOWER COST

Lincoln's increasing large-scale production has made possible installation of the world's most efficient equipment and methods for electrode manufacture. Lincoln has led the world in the reduction of electrode manufacturing cost and has continually passed the savings on to the user . . . for lower and lower welding cost.

Complete details and procedures for eight types of "Fleetweld" and 32 other Lincoln Electrodes are given in the "Weldirectory." Free on request.

THE LINCOLN ELECTRIC COMPANY • Cleveland 1, Ohio

America's greatest natural **recourse**

ARC WELDING

RESISTANCE WELDING CONTROL TRAINING COURSE

Designed to set forth in a clear and understandable manner how welding processes differ, how electronic control for resistance welding works and how this method of control extensively adapts this welding process to industry, a new seven-part training course by slide sound films, lesson books, quiz book and an instructor's manual has been prepared by Westinghouse.

Although produced primarily for Westinghouse employees, the material has been made available to others at reproduction costs because of many requests from engineering groups and individuals interested in resistance welding control.

It is recommended that 8 to 10 hr. should be allowed for the full seven-part course, 2 hr. for each of the four lessons. Lesson I to cover Parts One and Two, Lesson II to cover Parts Three, Four and Five, Lesson III to cover Part Six, Lesson IV for Part Seven and Quiz; with classes held one night each week, thus giving class members a chance for review and supplemental reading.

Material for the Course.—Slide films and records for the seven lessons give clear, visual explanations of the basic theory and applications (for use with 35-mm. sound slide film equipment). Seven lessons in handy picket size, reproducing the subject matter of each lesson, are provided each member of the class. These afford a convenient means of review and supplemental study. One quiz book is supplied each member of the class for final review of subjects covered. An instructor's manual giving suggested classroom procedure is provided with complete course. Informative booklets on resistance welding in industry supplement course material.

For a class of 20 a complete set of material costs $50 and includes the following:

20 sets—seven lesson booklets and Quiz book.
20 sets—supplemental literature.
1 set—seven slide films and records.
1 each—instructor's manual.

Orders for the resistance welding control training course should be sent to C. R. Riker, Supervisor, Extension Training, Westinghouse Electric and Manufacturing Co., 306 Fourth Ave., Room 1712, Pittsburgh, Pa.

ILLINOIS INSTITUTE OF TECHNOLOGY RESEARCH LABORATORY

The organization of a mechanics and aeronautics research laboratory to carry on long-time fundamental research in the field of solid and fluid mechanics has been announced by Illinois Institute of Technology, Chicago.

The laboratory will work in close cooperation with the mechanics and civil engineering departments and with Illinois Tech's Armour Research Foundation.

Dr. L. H. Donnell has been named director of the laboratory and Dr. LeVan Griffis, associate director. Both also serve as teachers of mechanics at Illinois Tech.

Dr. Donnell, who has been on the school's staff since 1939, was in charge of stress analysis and structural research for the Goodyear Zeppelin corporation for six years. Previously he headed the aeronautical structures laboratory at California Institute of Technology at Pasadena.

Dr. Griffis, who received both his undergraduate and graduate training at California Institute of Technology, had charge of the impact laboratory there before coming to Illinois Tech in 1941.

Four graduate students, two mechanics and a secretary assist the directors.

To help with financing the laboratory, sponsored projects will be accepted from outside organizations interested in research in solid and fluid mechanics.

Mr. Donnell indicates that the laboratory will undertake research in its broadest and most fundamental aspects rather than limiting itself to small, specifically detailed projects. He asks, therefore, that sponsoring agencies specify their problems in the broadest possible aspect. Problems for which ideas and plans have already been projected include the following:

The General Problem of Failure of Materials

Criteria for the three basic types of failure and other postfailure problems; significance of residual stresses in relation to failure; meaning and practical significance of ductility measurements and of impact tests; practical applications, including material cutting and forming operations, and failure of wire rope and of gear teeth.

Buckling Problems

The effect of imperfections of shape and elasticity on columns; development of complete and usable rational column theory; effect of imperfections on local buckling of thin curved sheet under axial stress; clearing up of present discrepancies in theories; extension of study of effect of imperfections to other cases.

Airfoil Problems

A study of several methods for reducing induced drag and their practical value, a study of airfoil sections by the use of adjustable models; a study of interfere effects produced by dihedral angles.

Problems in the Mechanism of Turbulen

Relation between wall roughness, tu bulence and friction loss; relations be tween roughness, turbulence, particle prop erties and transportation of solids.

The laboratory will encourage and at tempt to facilitate research by Illinois Tech faculty members who otherwise might find it difficult. It will assist re searchers by supplying and maintaining equipment and performing certain tech nical procedures.

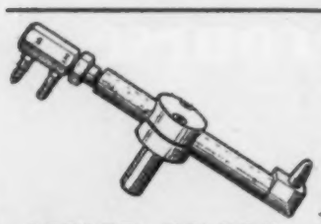
An advisory council, representing indus try, engineering societies and certain governmental agencies, has been formed. Participating are H. C. Boardman, head of research for the Chicago Bridge and Iron company; Dr. W. F. Durand, chairman of the National Research Council's Division of Engineering and Industrial Research; Dr. J. N. Goodier, chairman of the applied mechanics department at Cornell Univer sity; Dr. G. W. Lewis, director of aero nautical research for the National Ad visory Committee for Aeronautics; Prof. H. F. Moore, research professor of engineering materials at the University of Illinois; Dr. A. Nadai, consulting engineer for the Westinghouse Electric and Manufacturing Company; and Dr. S. Timoshenko, professor of theoretical and applied mechanics at Stanford University.

G.E. PAPERS AT A.I.E.E. CONVENTION

An interval timer for arc duration, the design of sealed ignitron rectifiers, power supply for a.-c. arc welders and an analysis of arc-welding reactors were among the subjects discussed in six papers by General Electric engineers during the Winter Technical Meeting of the American Institute of Electrical Engineers in New York, January 22nd to 26th.

Interval Timer for Arc Duration

A laboratory electronic instrument de veloped to measure the time in milli seconds during which arcing exists when an electric circuit is opened, was described in detail in the paper "An Interval Timer for Arc Duration," by J. S. Quill of General Electric's Industrial Control Engineering Division. The instrument, Mr. Quill ex plained, consists of a regulated power supply, a timing circuit, a voltage-signal circuit and a current-signal circuit. It re quires two input signals, one obtained from the arc voltage, the other from the circuit current. Timing is initiated when the volt tage signal appears and it is terminated when the current goes to zero. During the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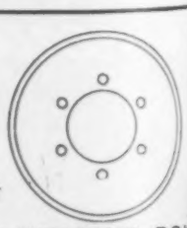
Butt
Flash
Spot
Seam
Projection
ELECTROLOY
Catalog and prices on request

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THE ELECTROLOY CO. INC. 1600 SEAVIEW AVE. BRIDGEPORT, CONN. WELDING ROLL

# of X-ray Quality Welding

X-RAY welding is synonymous with top welding quality. And more than a mile of X-ray quality welding is done in A. O. Smith plants *every day!*

This mastery of welding technique made possible an unprecedented increase in the speed of aerial and submarine torpedo production — two of the most lethal weapons of the war at sea.

Moreover, for torpedo air flask welding, A. O. Smith had to develop a new electrode in order to weld the high-strength alloy steel, and still meet the highest X-ray standards.

This vital wartime development is one more evidence of the supremacy of SMITHway Certified Welding Electrodes. More than 320,000 of these electrodes are used daily in A. O. Smith plants. Millions more are used in other manufacturers' plants.

Make the most of modern welding as a production tool. Write for catalog, and outline your welding problems.

Buy an Extra War Bond This Month!

Mild Steel . . . High Tensile . . . and Stainless Steel WELDING ELECTRODES

made by welders . . . for welders

SMITHway Welding Monitor trains better welders, faster.

SMITHway A. C. Welding Machine saves power; eliminates arc blow.

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SMITHway CERTIFIED WELDING ELECTRODES

interim, a capacitor is charged linearly with time, and the voltage on the capacitor is inversely proportional to the arc time. The characteristics of this timer, Mr. Quill stated, make it very suitable for dealing with the problems of both a.-c. and d.-c. arc interruption. It is readily set up and seldom requires readjustment, it reads directly and thus eliminates lengthy and expensive photographic processes, and with it only a few minutes are required to complete a test of 100 interruptions with the arc time recorded for each operation. The timer may also be used to measure the interval between two voltage signals, the opening and closing of travel time contactors, the sequencing of devices and for many similar applications. One of these timers, Mr. Quill pointed out, has been in use for approximately a year, during which period it has recorded over a quarter of a million readings of arc time.

Sealed Ignitron Rectifier Design

In the paper "Design of Sealed Ignitron Rectifiers for Three-wire Service," M. M. Morack of the Power Rectifier Engineering Division discussed the various advantages offered by three-wire sealed ignitron rectifiers. In general, Mr. Morack stated, these rectifiers consist of the following components: (*a*) metal-enclosed, manually or automatically operated a.-c. switchgear, (*b*) main power transformer or autotransformer, (*c*) metal-enclosed, water-cooled sealed ignitron rectifier and excitation equipment and (*d*) metal-enclosed, manually or automatically operated d.-c. switchgear. Describing their operation in detail, Mr. Morack emphasized that these rectifiers are particularly designed for supplying d.-c. power to industrial three-wire systems as well as to metropolitan districts where it is uneconomical to rewire large buildings for a 208-v., three-phase, 60-cycle supply or to replace d.-c. motors and controls for a.-c. operation. The rectifiers, the speaker said, require little space, operate quietly and their no-load losses are small and their efficiency fairly constant and reasonably high over the entire load range. In addition, since they are factory assembled as unit d.-c. substations, installation time and expense are minimized.

Power Supply for A.-C. Arc Welding

The load put on power circuits because of the steadily increasing use of a.-c. arc welding, and useful data for determining the effects of this load on power circuits generally, were discussed in "Power Supply for A-C Arc Welding," by R. F. Wyer of the Electric Welding Division and A. U. Welch of the Power Transformer Engineering Division. Clearly indicating the sharp difference between arc welding and resistance welding from the standpoint of power supply, the authors of the paper emphasized that a.-c. arc welders may be divided into two general types: industrial welders and utility welders. Industrial welders are built for primary power circuits of 220-, 440- and 550-v. ratings, and step down the voltage to approximately 75. These welders are designed for high-speed, quality welding, quick and easy starting, and are capable of being used with long welding leads. Utility welders are built in low current ratings, usually 200 amp. and below, and are characterized by low open-circuit voltage, low kilovolt-ampere demand, simple construction and reasonable cost. Welders of this type are designed for use in small repair shops where their slow arc starting, slow operation and current variation with arc length are not tooobjectionable. Themajor portion of the paper was devoted to a description of the operation of various types of industrial welders and the extent to which their individual operation affects power circuits.

Analysis of Arc-Welding Rectifiers

The paper, "Analysis of Arc Welding Reactors," by Charles M. Wheeler of the Motor Engineering Division, not only high lighted the need and the design of reactors for d.-c. arc-welding sets, but defined the inductance useful in stabilizing welding arcs and suggested methods for calculating and measuring this quantity. The paper also described a recent development in reactor design. Long experience, Mr. Wheeler pointed out, established the desirability of self-reactance in d.-c. arc-welding circuits. Although it was originally common practice to use large welding reactors with most arc-welding generators,

MOR-WELD HOLDERS
Last
FROM 20 TO 30 TIMES LONGER
Due to Special Plastic Compound Used in Jaws
Scientifically Simple!
COUNT THE ABOVE FEATURES
1. "Everlast" plastic jaw cover. 2. Heavy duty cast bronze, cadmium plated jaws extend into both insulated handles. 3. Spring tension applied direct to upper jaw. 4. Over-strength jaw bearing. 5. Heavy male contact rod. 6. Steel coil, rod grip tension spring. 7. Adjustable tension thread. 8. Rear female contact rod. 9. Insulating red fibre handle. 10. Electric cable connector block.
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CORPORATION
DESIGNERS AND PRODUCERS OF SPECIAL EQUIPMENT
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Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"

Ask for Them *Unequalled for Quality*

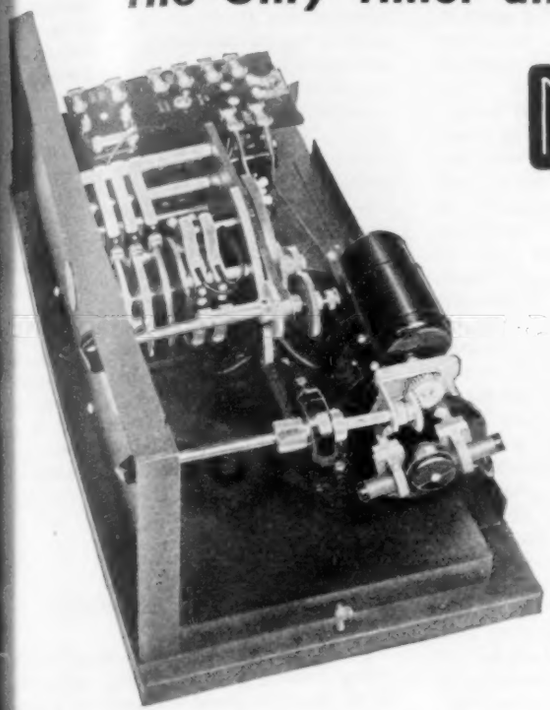
A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; No. 16 Silver Solder Paste Flux.

ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana

Time Counts—
Gas cut and Weld with
Shawinigan Carbide

SHAWINIGAN
SHAWINIGAN PRODUCTS CORPORATION
EMPIRE STATE BUILDING, NEW YORK 1, N.Y.

The Only Timer an Operator Can Service Himself!



NATIONAL

SYNCHRONOUS

DUO-TROL WELD-TIMER

With Heat Control

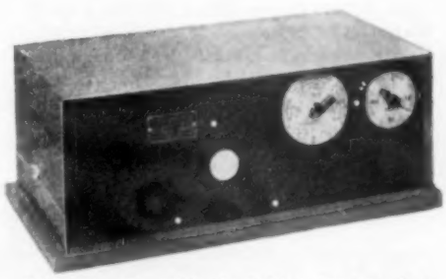
TYPE NO. 1841 P

A COMPLETE SEQUENCE PANEL

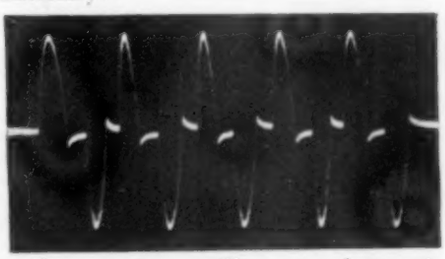
Above: National Duo-Trol from right side, with cover removed. Note accessibility of every part, every function. Heat Control rotating commutator is shown attached to motor shaft, with opposed brushes, through which the Ignitron tube firing circuit passes. The position of brushes establishes the firing point on the sine wave; and is regulated by dial knob on front panel.

- National Duo-Trol Lasts Longer
- Easy to Keep in Constant Operation
- Requires Less Maintenance

Here is the finest Weld-Timer made—built by National to high precision standards. It costs more to manufacture than any other timer in our line—and it is worth it! This is our Aircraft Unit, but it is also used on critical alloys, such as stainless steel, for the most important types of war products. If YOU have a resistance welding problem, requiring consistent, uniform output that must pass Army-Navy qualifying tests, you need National Duo-Trol . . . And, after the war, your Duo-Trol will be equally serviceable on peacetime products.



Here is Duo-Trol fully enclosed in sheet metal cabinet. Loosen 2-wing nuts to remove cover. Knock-outs are provided on left, for wire entrance. Right Dial regulates Heat. Left Dial varies weld-time. Squeeze and hold intervals follow weld interval automatically.



Above. An oscillogram of 5-cycle Weld Interval, with Heat-Control dial set at 22. Note the effect of Phase Shifting, or delayed firing, that has reduced the available heat about 50%.

Small in size, compact, and easy to keep in constant running order—Duo-Trol will always prove its worth. Get all the facts—write us—DO IT NOW!

NATIONAL TIME & SIGNAL CORPORATION

600 E. MILWAUKEE AVENUE DETROIT 2, MICHIGAN

subsequent refinements in generator design and improved welding electrodes resulted in gradual abandonment of the practice. The wide application of 3600-rpm. welding sets have placed a new emphasis on the use of external reactors, and the design of these reactors merits special attention since their size and weight must bear favorable relationship to that of the rest of the equipment. Several methods of calculating welding inductance, i.e., the rate of change of flux linkages per change in current, by graphical means and for measuring it from oscillographic tests, were suggested by the speaker. The paper was concluded with a description of a new arc-welding reactor, consisting solely of a U-shaped core and a winding, which is mounted on the welding generator in such a way that the magnet frame completes its magnetic circuit. Although the primary function of this new reactor is to supply inductance, by reason of its integration with the generator its transient characteristics are improved and smaller, lighter weight designs are made possible.

Measurement of Stray Load Losses in Induction Motors

In the paper "Measurement of Stray Load Losses in Induction Motors," D. H. Ware of the Induction Motor Engineering Division presented test data confirming the accuracy of the reverse rotation method for the direct measurement of stray load loss in polyphase induction motors. The efficiency of an induction motor, the speaker stated, may be determined with reasonable accuracy by several methods. One is the so-called input-output method, by which the motor is loaded to normal load and the electrical input and mechanical shaft output are measured. This method, while precise, is difficult to perform since large quantities must be measured to determine a smaller one, and then often the necessary power supply and loading equipment are not available to load large motors fully under conditions where accurate measurements may be taken. By another method, the segregated loss method, the values of the primary copper loss, the secondary copper loss, the core loss, the friction and windage loss and the stray load loss must be measured and the efficiency of the motor determined from the sum of these values. The first four of these values can be measured easily, accurately and by comparatively direct methods. Stray load loss, however, is more difficult to measure directly. Mr. Ware then proposed a correction for the reverse rotation test for measuring stray load loss in polyphase induction motors and presented in considerable detail the test data which confirm the facility and accuracy of the reverse rotation method as corrected. This correction is particularly necessary in those motors rated from 500 to 1000 hp. and larger.

Principles of Grid Control for Thyratrons

A preamble to the study of practical circuits for grid control of thyratrons was presented in the paper "Principles of Grid Control for Thyratrons," by P. H. Chin and E. E. Moyer of the Industrial Control Engineering Division. Introducing their subject with a comprehensive classification of thyratron tubes, the authors presented an interesting summarization of the phenomena of gaseous conduction in thyratrons. Next described were the critical grid characteristics of thyratrons and their behavior with a.-c. potential on the anode. The basic methods of grid control of thyratrons—control by d.-c. grid potential, by a.-c. potential and by a combination of a.-c. and d.-c. grid potentials—were then explained in interesting detail. Sharp emphasis was placed on the fact that although numerous circuits for grid control are employed in various types of electronic control systems, with rare exceptions, all of these circuits are derived from these three basic methods. The paper was concluded with a presentation of universal grid control curves for combined d.-c. and sinusoidal a.-c. grid potentials.

TOMMY SMITH PROMOTED

Promotion of Thomas B. Smith to the newly created post of welding engineer in U. S. Steel's Federal shipyards at Kearny and Port Newark, N. J., was announced by Lynn H. Korndorff, President.

Mr. Smith will now devote his entire time to the advancement of welding procedures and practices in the two Federal yards. He has pioneered in the application of welding to ship construction a

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More and more in important places UNITED tubes are becoming first choice for Resistance Welding use. Not only do these tubes look better and perform better but they average many thousands of hours satisfactory operating life. Next time you need tubes try United tubes and let the performance record tell the story.

WRITE FOR A TUBE CATALOG

UNITED ELECTRONICS COMPANY
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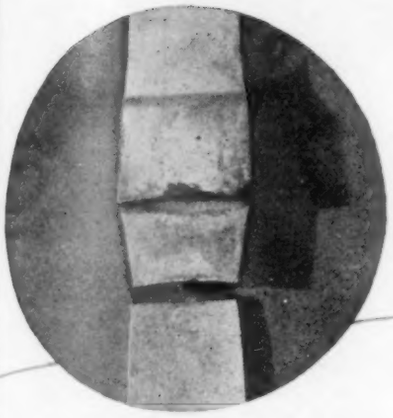


Strength of this joint is indicated by test section where parent metal failed in test which left brazed joint intact.

Intricate machined or cast parts are being discarded, more and more, to be replaced by built-up structures joined by brazing. This is particularly true with the increasing adoption of Phos-Copper for brazing copper, brass and bronze.

With this unusual alloy, tests and actual operations have shown brazed joints stronger than the parent metal . . . corrosion resistance equaling the parent metal . . . electrical conductivity 98% as great. Its low free-flowing temperature has saved time as well as permitted the brazing of lighter sections. Further, these are the reasons why Phos-Copper is replacing tin and silver-base solders.

Phos-Copper brazing may be done in any of five ways—by gas, incandescent carbon, dipping and electronic heat, and in a furnace. It is furnished in rod, strip and special shapes.

For further information on Phos-Copper, ask your Westinghouse representative for book B-3201. Or request it from Westinghouse Electric & Manufacturing Company, P.O. Box 868, Pittsburgh 30, Pennsylvania.

J-90555

WILL BRAZING SIMPLIFY YOUR PRODUCT DESIGN OR CUT YOUR COSTS?

—since PHOS-COPPER gives these ten advantages!

1. Low melting point
2. Excellent capillary action
3. Self-fluxing on most work
4. Strength
5. Absolute uniformity
6. Fatigue resistance
7. High electrical conductivity
8. Corrosion resistance
9. Can be tinned or electroplated
10. Lower first cost

Parts similar to these have been made by casting and machining, by forging and by upsetting. These parts are produced inexpensively by brazing a collar block to a length of standard tubing.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Phos-Copper Brazing

Thomas B. Smith

Federal for 26 yr. When he was employed on Dec. 9, 1918, that art was used only for mending tools and other odd jobs in the maintenance department.

Entire ships are now sewed together with hand and automatic welding arcs, thereby reducing maintenance costs and increasing the carrying capacity of vessels by 30%. That resulted from design changes which eliminated angles, brackets, gusset plates and other parts that were necessary when ships were riveted together as in the first World War

Large-scale welding of ships at Federal was begun with the construction of the four Santa liners in 1941 and 1942 for the Grace Line. Federal had prepared in 1918 to experiment in welding for the Emergency Fleet Corp., which was interested in the possibilities of an all-welded ship. The project was cancelled by the goverment shortly after the end of the first World War.

Special pipe to accommodate high-pressure, high-temperature steam for ship propulsion was first welded at Federal on the passenger ship *Dixie*, delivered Jan. 16, 1928. This pipe carried steam of 620° temperature and 350 lb. pressure. Research at Federal played a major role in developing the new driving power that has proved an advantage to ships of the United States Navy in the present war.

At peak employment in September 1943 there were 3000 welders in the department at Kearny of which Mr. Smith was the General Foreman, and 1800 in the welding department at the Port Newark yard, which Mr. Smith established.

Mr. Smith has served on various governmental committees concerned with welding and has been a member of the AMERICAN WELDING SOCIETY since 1922. He was chairman in 1944 of the New Jersey Section of the SOCIETY and is now a member of the board of directors of the section. It was under his direction that welding schools were begun in Elizabeth, Bayonne, Newark and Jersey City, for the National Defense Program.

Born in Jersey City, N. J., on June 10, 1901, Mr. Smith resides at 30 Headley Place, Maplewood, N. J., with his wife, the former Miss Gertrude R. Sweeden, of Jersey City, their son, Donald, 11 years old, and daughter, Ruth, eight years old. Another son, Thomas B. Smith, Jr., 18 years of age, has just completed his training as a private in the U. S. Marine Corps on Paris Island, S. C.

NEW COMPANY BEING FORMED TO MAKE WELDING MACHINES

Precision Welder and Machine Co. has been formed in Cincinnati, Ohio, by two widely known men in the resistance welding field, it was announced. The new company will build a complete line of spot, projection, seam and flash butt welding equipment, officials announced.

T. Embury Jones, until recently vice-president and manager of the Welder Division of Federal Machine and Welder Co., Warren, Ohio, is slated to be elected president and treasurer of the new company. E. W. Forkner, formerly chief engineer and production manager of Federal, is to be vice-president in charge of operations.

T. Embury Jones

This new company was attracted to Cincinnati because of the central location for industrial development and because of its prominence as the home of precision-built machine tools, officials explained.

It will be located at English and Neave Sts. in a brick building having 7500 square feet of floor space.

Resistance welders are widely used in vital war programs, such as heavy ammunition, rockets and aircraft, as well as in peacetime production of refrigerators, automobiles, metal furniture and various sheet metal products, officials said.

E. W. Forkner

STEEL CASTINGS

An unusually attractive and informative brochure on the Steel Castings Industry and its importance to America has been issued by the Steel Founders' Society of America, 920 Midland Building, Cleveland, Ohio. Copies available on request of that organization.

NEW SLIDE FILMS FOR TEACHING OXYACETYLENE PROCESSES

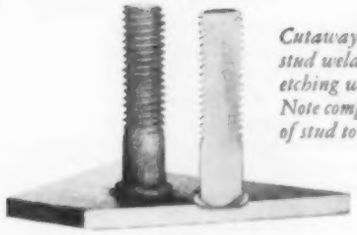
An industrial teaching aid in the form of a series of how-to-do-it slide films and accompanying instruction literature on oxyacetylene welding and cutting operations has recently been completed by The Linde Air Products Co., a Unit of Union Carbide and Carbon Corp. Carefully planned to be adaptable to streamlined wartime production as well as to the tempo of peacetime, to the needs of the beginner and the "old timer," the lessons are presented as a step-by-step procedure and cover the basic techniques of welding and cutting.

This New Method of Teaching Oxy-Acetylene Welding and Cutting Techniques Will Do the Job Easier, Better and Faster

The shop superintendent, foreman, safety supervisor or welding instructor who must supervise such instruction will find in this program a well-planned course immediately available to his needs. Very often such a person, skilled in the proper techniques himself, can be helped by placing in his hands an effective aid for teaching these techniques to others. An instructor's manual with suggestions on accepted teaching procedures is provided and should prove particularly helpful to him. Each slide film comes with three of

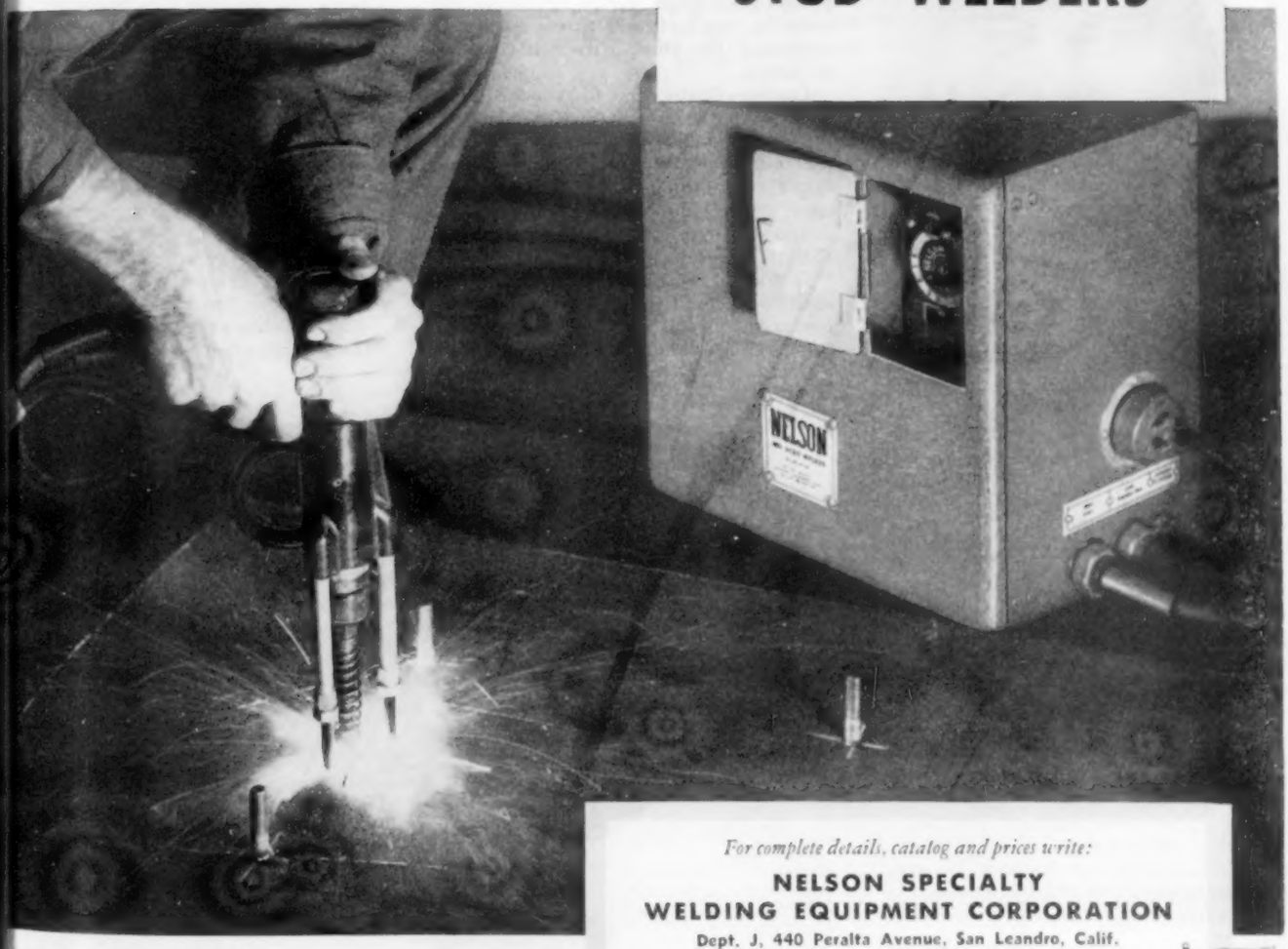
Automatically end-weld studs!

- Complete fusion between stud and metal in ½ second . . . Saves time.
- No drilling holes or hand-welding bolts. Studs are pointed for accurate locating.
- One operator can weld more than 1000 studs per shift. Completely portable. Also available as a production jig.
- Thousands of guns now being used in more than 500 shipyards and industrial plants.



Cutaway view of stud weld after etching with Nital. Note complete fusion of stud to metal.

NELSON
ELECTRIC ARC
STUD WELDERS



End-welding a stud to metal plate.

For complete details, catalog and prices write:

NELSON SPECIALTY WELDING EQUIPMENT CORPORATION

Dept. J, 440 Peralta Avenue, San Leandro, Calif.

Eastern Representative: Camden Stud Welding Corp. Dept. 122, 1416 South 6th Street, Camden, N. J.

these instructor's handbooks, and 25 student handbooks, which contain a written record of the step-by-step procedures shown in the film. The film is a succession of pictures, in regular 35-mm. motion picture film that can be projected on a screen one at a time as still pictures, while the instructor comments or answers questions.

Linde slide films and accompanying literature are now completed and ready for distribution. They may be obtained through any office of The Linde Air Products Co. at a nominal price. Any Linde representative will aid in the selection of slide films and the planning and organization of individual training programs.

FRITSCH ELECTED PRESIDENT TUBE TURNS

R. E. Fritsch, Vice-President of Tube Turns, Louisville, Ky., since 1929, has been elected President, succeeding Walter H. Girdler, Sr., who died on January 7th. He joined Mr. Girdler when Tube Turns was originally organized and he has had a major part in the firm's rapid growth.

R. E. Fritsch

Mr. Fritsch continues as Vice-President and a member of the board of directors of The Girdler Corp., of which Tube Turns is an affiliate. He is a member of the American Society for Metals and the AMERICAN WELDING SOCIETY.

Tube Turns manufactures seamless welding fittings and flanges for ships, power plants, refineries and many other purposes, and is a large-scale producer of aluminum and steel forgings for industry.

ARC WELDING IN THE DESIGN AND FABRICATION OF GEAR CASE FOR RECIPROCATING PUMP*

Steel castings have been long considered as the only practical housing for gear cases on large reciprocating pumps such as the one discussed in this paper. Castings have been frequently redesigned to cut down weight and many expensive patterns have been made in an attempt to accomplish this same thing.

The particular housing discussed here is that designed for a 5-cylinder, 6-in. reciprocating pump of the type used by oil pipe-line companies to pump oil. These pumps work under varied conditions and must be well built and strong enough to withstand the abuse to which they are subjected.

Castings finally came to be looked upon with some question because of the ever present possibility of porousness of castings, their high cost, and because of considerable difficulty in flame cutting the cases. Steel plate fabricated and welded appeared to be the answer and solution to these many problems.

It was found that $^1/_2$-in. steel plate would withstand the stresses of this particular pump and that 3-in. plate would stand the maximum load of the bearings. With this information and without the aid of expensive patterns, work began to fabricate such a gear case. The $^1/_2$-in. sheet was flame cut and shaped, fitted and welded. Rod of AMERICAN WELDING SOCIETY specifications, E6010, was used throughout the welding operations.

The bearing housing was flame cut and welded into position into the formed and welded case. Figure 1 shows the case on its back with the shaft housing and bearings partially completed and welded. The mountings or stands were flame cut and then welded and this gives a good idea of the problem and solution to the problem on gear cases, in that the most difficult part of the job is now done. At this point every dimension was checked and no distortion from welding was found. The system of first tack welding then completing with an even weld is responsible for the lack of distortion.

Figure 2 shows the completed gear case. The fabrication work took 70 hr.,

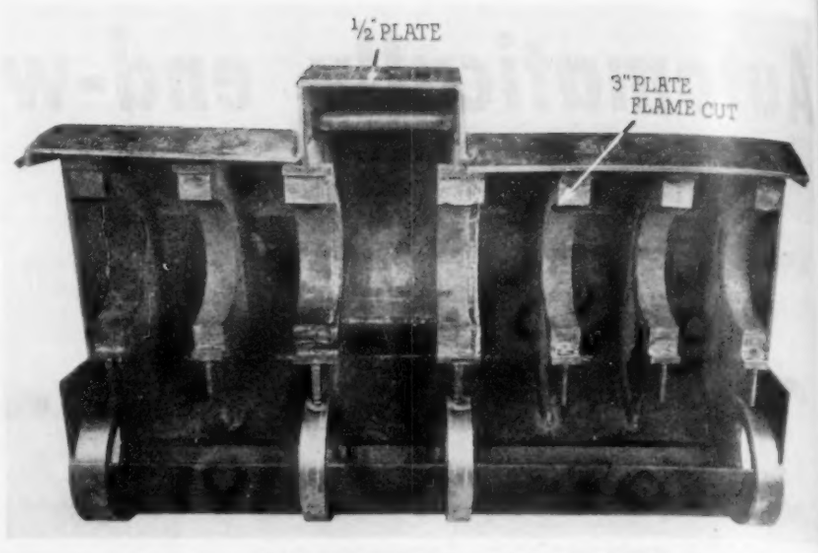


Fig. 1—A View of the Welded Structure with Welded Shaft Housing and Bearings Installed

Fig. 2—View of Completed Gear Case Welded to Second Assembly to Form One Integral Unit

*From a paper submitted by J. C. McKinley, President, Apex Mach. & Mfg. Co., Tulsa, Okla., in the Industrial Progress Award Program sponsored by The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

IS THE INITIAL COST OF FERRO MANGANESE THE FINAL COST?

FERRO MANGANESE granulated for the extruded welding rod industry falls into two general classifications:

1. A product controlled between a passer and a duster screen.

2. A product ground through a passer screen only.

Product 1 will cost more to produce than product 2, but here at Foote it is believed that the additional expense is justified for the following reasons:

1. Removal of excess fines passing the 325 mesh screen reduces the percentage of Manganese that would otherwise be oxidized in the arcing process and consequently lost as far as weld metal pickup is concerned.

2. Reduction of the percentage of fines through the 325 mesh screen decreases the surface exposed per pound of Ferro Manganese, thus reducing gassing difficulties and changing batch viscosities.

Lump of Ferro Manganese surrounded by Granulations

3. Increasing importance is being assigned to the role of particle size control in rod behavior, bonding and drying characteristics of the rod coating. Control of particle size gradation can best be accomplished by imposing rigid specifications on both ends of the particle size range; it cannot be attained by a passer screen guarantee alone!

THE BOMB THAT BECAME A SEED

In a glass bomb such as this, Foote produces pure Ductile Zirconium by deposition. Ductile Zirconium is rapidly increasing in use, becoming the seed of many new and interesting developments. The deposition process, improved and perfected by Foote engineers, is only one example of Foote's forward march in ores, minerals, alloys and chemicals.

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thereby considerable reduction was effected in the cost to the user. A comparison in cost is shown below:

Comparative Cost

Item	Welded Const.	Cast Cost	Pattern Cost
Gear case	$1375	$1046.25	$500

Savings, $171.25

This saving in actual cost, is of course, worth while, but there were other points of merit which should be considered; for example:

Comparative Weights

Item	Cast Weight, Lb.	Fabricated Weight, Lb.
Gear case	2500	1815

Therefore, a further saving in weight of 685 lb. was effected. This resulted in further money saving to the user because of the lesser amount of freight involved in transportation.

Further, the unit was greater in strength and was easier to move making the gears more accessible for repair. The welded case was not likely to break or fracture in handling, hence, increasing the safety factor of its use.

There is one climaxing factor of great importance during these times in that less steel was used for the whole job making more available for our war program.

The user highly recommends this case and plans to use it on future pumps.

SUSTAINING MEMBERS

International Harvester Co., Chicago, Ill., manufacturers of farm machinery—plows and tillage, planting and seeding, cultivating, and harvesting machines; motor trucks; farm tractors of the Farmall and 4-wheel types; industrial power equipment, including several models of crawler-type tractors; refrigeration equipment; binder twine and steel products for domestic and international markets. Currently producing a wide variety of military products, including military tractors and motor trucks, shells, aircraft torpedoes, gun carriages, fuses, high-speed prime movers, etc.

Isaacson Iron Works, Seattle 14, Wash., structural steel, press hammer forgings, plate fabrication, custom steel makers, tractor equipment and galvanizing. During the past few years Isaacson Iron Works has shown special interest in the welding of structural steel. Their "know how" should be of great benefit again to their many customers when the restrictions of war are lifted. Their structural shop is now jammed with gun sponsons, bulkheads, platforms and miscellaneous ship parts for many Pacific coast shipyards.

Employment Service Bulletin

POSITIONS VACANT

V-154. Spotweld Engineer wanted by Connecticut aircraft company. Maintenance, control or development experience with aluminum resistance welding necessary. Must be familiar with all types of resistance-welding equipment. Write giving experience and salary required.

V-155. Wanted: Electrical engineering graduate with experience in electronics, preferably in the electronic control of resistance seam welding machines for light gage steel sheets. Position will be "for the duration." Salary from $375 to $475 per month, plus a living allowing of $7 per day.

SECTION ACTIVITIES

BOSTON

C. J. Burch of The Linde Air Products Co. addressed the January 8th meeting on a "New Oxyacetylene Welding Development."

On February 12, Harold N. Ewertz, Past-Chairman of the Boston Section and Philadelphia District Manager of American Machine & Metals, Inc., spoke on "Welding of Stainless Steel." R. J. Pass, Sales Director of Tempil Corp., discussed "Tempil Products and Their Applications."

BRUNSWICK

The January meeting was held on the 18th at the Hotel Oglethorpe. G. E. films on a.-c. and d.-c. welding were shown. An interesting discussion followed.

CHATTANOOGA

The regular monthly meeting of this Section was held on Friday, January 12th, in the auditorium of the Electric Power Board. William C. Cuntz of the Metal & Thermit Corp., Pittsburgh, spoke on "Thermit Welding in Theory and Practice." Mr. Cuntz also showed colored sound movies on the subject.

CHICAGO

The January meeting of the Chicago Section was held on January 19th. The guest speaker of the evening was John H. Gallaher, Haynes Stellite Corp., Chicago, Ill.

Mr. Gallaher spoke on "Welding Hastelloy Alloys." In a prepared paper Mr. Gallaher described many applications of Hastelloy in present-day refinery equipment. He pointed out that in some of the pressure vessels now being built to withstand corrosion by the use of Hastelloy linings as much as two miles of welding were involved in the course of construction. Some of these applications were illustrated by slides. All in all, it was an interesting and enlightening meeting.

Preceding the speaker, a movie, "Railroadin'," was shown through the courtesy of American Locomotive Co. and General Electric Co.

CLEVELAND

H. W. Lawson, one of the foremost authorities on welded buildings and bridges, spoke before the January 10th meeting. Mr. Lawson is Structural Engineer for the Bethlehem Steel Co. Esther Mullin, director of women's activities of radio station WGAR and instructor of drama at Western Reserve University, gave the coffee talk.

A thorough analysis of America's foreign policy and diplomatic relations was given by George C. A. Hantelman, Secretary-Manager of the Cleveland Engineering Society at the meeting on February 14th. Mr. Hantelman, a noted lecturer, author and editor, spoke from first-hand knowledge of Europe and its conditions. Educated at the University of Leipzig and the Sorbonne in Paris, he also attended Wittenberg College and Vanderbilt University in this country. His world travels have made him many contacts which aid him in his analysis of world affairs.

Jeff Carlin, colorful figure in sports and head basketball coach at Case School of Applied Science and assistant football coach, 4-letter man de-luxe at Washington and Jefferson University when he attended college, spoke at the dinner.

COLUMBUS

The regular monthly meeting of the Columbus Section was held on January 12th at Battelle Memorial Institute. Dean C. E. MacQuigg of Ohio State University spoke on "Pressure Welding."

The February meeting, held on the 9th at the Southern Hotel, was addressed by R. E. Long, Chief Engineer, National Cylinder Gas Co., Hollup Corp., who spoke on "Why Different Types of Electrode Coatings?"

DETROIT

Problems in welding copper and copper

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MILD STEEL ELECTRODES

Type—RACO	7, All Position, Reversed Polarity	AWS E-6010
"	11, All Position, A. C.	AWS E-6011
"	8, General Purpose, Poor Fit-up	AWS E-6012
"	13, General Purpose, Light Gauge	AWS E-6013
"	20, Horizontal Fillets	AWS E-6020
"	5, Deep Grooves	AWS E-6030

HIGH TENSILE STEEL ELECTRODES

Type—RACO	74, All Position, Reversed Polarity	AWS E-7010
"	64, Horizontal Fillets	AWS E-7020

STAINLESS STEEL ELECTRODES

Type—RACOLLOY	18-8, Unstabilized	Type 308
"	18-8Cb, Stabilized	Type 347
"	18-8(1.5% Mo)	Type 316
"	18-12(2-3% Mo)	Type 317
"	18-12(3-4% Mo)	Type 307
"	19-9, For Welding air-hardening steels	Type 309
"	25-12, Unstabilized	Type 310
"	25-12Cb, Stabilized	
"	25-20, Scale-resisting steel	

HARD SURFACING ELECTRODES

Type—RACO 25, 20-25 C Rockwell (Machinable Deposits)
" 45, 40-50 C Rockwell
" 55, 50-60 C Rockwell
RACOLLOY Manganese, Austenitic Manganese Steel

LIGHTLY COATED ELECTRODES

Type—Blue Label, Sull Coated, Manual Welding		AWS E-4510
Type "D" Automatic or Manual Welding		AWS E-4520
Type "D" .30-.40 C, For surfacing		AWS E-4520
Type "M" Automatic Welding		

OXY-ACETYLENE WELDING RODS

Type—Red Label Copper Coated Mild Steel
Red Label Copper Coated Pure Iron
RACO High-Tensile, For High-Tensile Steels

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SINCE 1919 PRODUCERS OF ARC WELDING ELECTRODES AND WELDING RODS

alloys were outlined before the Detroit Section at its February 6th meeting by J. J. Vreeland, Metallurgical Engineer of the Chase Brass & Copper Co. Criteria for production methods of welding, he said, included cost, weather-use conditions including exposure to corrosion, thermal and electrical conductivity requirements and production speed. Cleanliness was said to be especially important in welding of copper and brass, and adequate jigging is also a major factor.

Mr. Vreeland's paper covered various methods of welding, including oxyacetylene, electric arc, carbon arc and resistance welding. In each case he described good and bad practices, and made a wide variety of recommendations as to types of rod and other factors involved.

FLINT

The Flint Division of the Detroit Section heard a discussion on repair of automotive castings by welding, presented by Fred J. Walls, Research Metallurgist of the International Nickel Co. Mr. Walls described recommended practices and latest developments in repair art, as recommended by private industry and by ordnance.

INDIANA

The January meeting was held on the 26th at the Riley Hotel, Indianapolis. T. B. Jefferson, Editor, *The Welding Engineer*, spoke on "Welding in the Postwar World."

KANSAS CITY

G. N. Sieger, President of SMS Corporation, Detroit, addressed the January 23rd meeting, on "Resistance Welding." He covered briefly the fundamentals involved, stressing the three salient factors of time, pressure and current. The selection of tips, methods of cooling and cleaning of material were also discussed. A film prepared for the Navy, showing welding processes used in aircraft production, was shown.

J. W. Kenefic of the Air Reduction Sales Co. will address the March 20th meeting on "Railroad Welding." Dinner at 6:30 P.M. in the Pine Room, Fred Harveys, Union Station.

LEHIGH VALLEY

The regular monthly meeting of the Lehigh Valley Section was held on Monday, February 5th, at the Hotel Bethlehem, Bethlehem, Pa.

The guest speaker of the evening was William Spraragen. In the talk following the dinner, Mr. Spraragen sketched the organization history of the Welding Research Council and the AMERICAN WELDING SOCIETY. He paid special tribute to the welding research work which has been done at Lehigh University.

Mr. Spraragen also participated as a member of the Panel Discussion. The other panel members who are also members of the Lehigh Valley Section were Warren Taylor, H. W. Lawson, R. E. Sommers, E. W. David, P. H. Barron and J. W. Kenworthy. The moderator for the discussion was H. O. Hill. Mr. Hill opened the discussion by citing much of the printed matter on codes, specifications and practices which the A.W.S. publishes. Questions, which were presented from the floor, concerned qualification of welders, structural details, welding metallurgy, X-ray inspection, acetylene welding and resistance welding.

Chairman Kenworthy concluded the meeting with the showing of a United States Navy sound film on Resistance Welding.

LOS ANGELES

The January dinner meeting of the Los Angeles Section was held on January 18th, at Scully's Restaurant with 150 attending. First speaker to be introduced was A. R. Wynn, Welding Engineer, U. S. Naval Dry Dock, Long Beach, Calif. "Making Up Your Mind" was the title of his coffee talk. Our extreme need for making decisions was stressed and highlighted.

Second and principal speaker was J. P. Weed, General Foreman, North American Aviation, Inc., Los Angeles, Calif. "Production Brazing" was the topic of his presentation which described methods employed and results obtained by the use of silver brazing. This method for fabrication of precision parts multiplied production output of parts for the famous "Mustang Fighter" without increasing personnel. Dip, torch, furnace and induction methods of brazing were discussed describing particular applications of each. Color photo slides were projected realistically showing equipment and jig setups. Sectioned parts were presented for inspection by the group.

Concluding feature on the program was showing of the film "Oil for War," an exceptional portrayal of welded pipe-line construction.

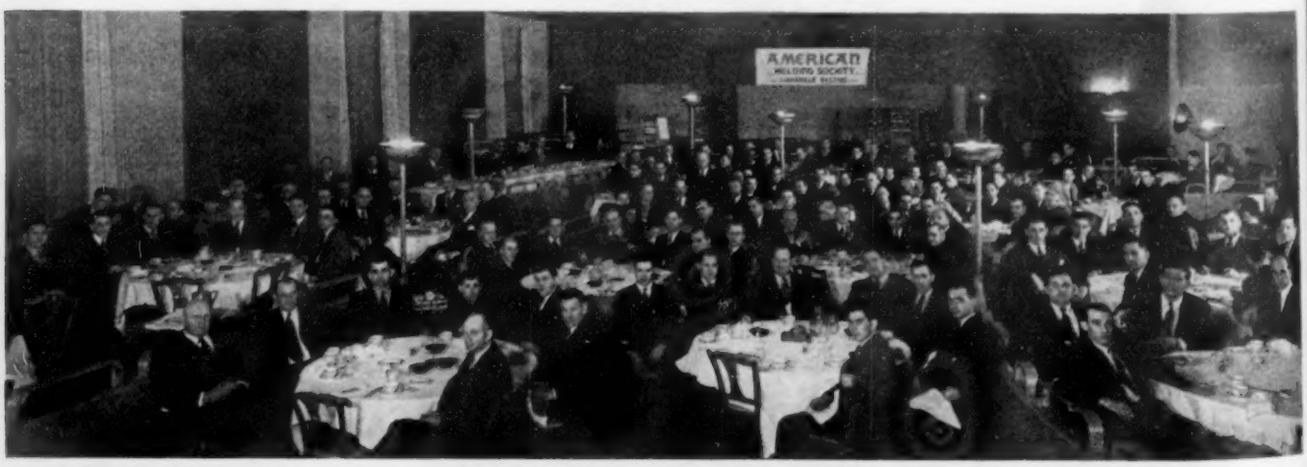
LOUISVILLE

A. C. Weigel, President A.W.S., was our guest on the evening of Tuesday, February 27, 1945.

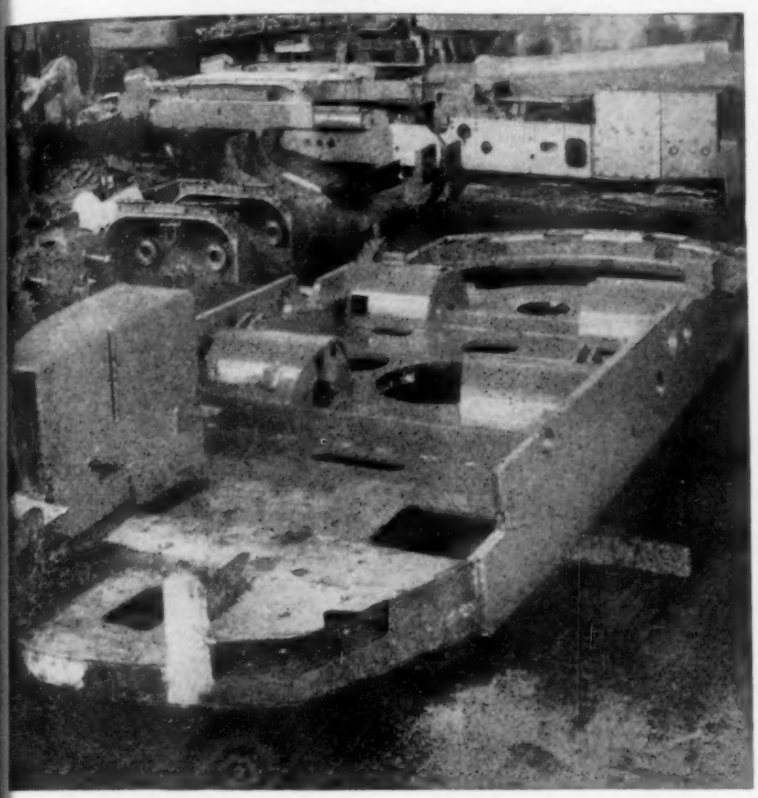
Our January 22, 1945, Dinner Meeting went over with a "big-bang!" It turned out to be a real Kentuckiana Home Folks Gathering of 175 members and guests with "featured" Kentuckiana speakers, welding displays and exhibits and good cuisine eaten to the melodic strains of splendid dinner music. A news flash came out that our genial master of ceremonies, R. E. Fritsch, had been promoted to the presidency of Tube Turns, Inc., and at the psychological moment the assemblage broke out in song to the tune of "Happy Birthday," substituting Happy Promotion Dear Rudy—Happy Promotion to You."

Our Kentuckiana speakers were introduced by Mr. Fritsch in order named and their subjects: (1) K. P. Vinsel, Executive Director, Louisville Area Development Association, presenting "Louisville Plans for the Future." We know now that Louisville is "going places industrially" in a big way. (2) G. C. Williams, Associate Professor, Chemical Engineer, University of Louisville. He emphasized that "welding is an important tool in the metal industry and the *welder* an important cog who must cooperate." (3) H. C. Powers, General Supervisor of Welding, American Air Filter Co., presented "Oxy-acetylene Welding of Light-gage Metals to Reduce Distortion by the Use of the Chilling Bar Method." An appropriate welding display was used to back up his thesis.

In summation: We are improving in attendance, good fellowship, crowd mixing and our M. C. hit the "jack-pot" in using the "Wisdom of Solomon, the patience of Job and the diplomacy of an English diplomat" in doing an unusually good job.



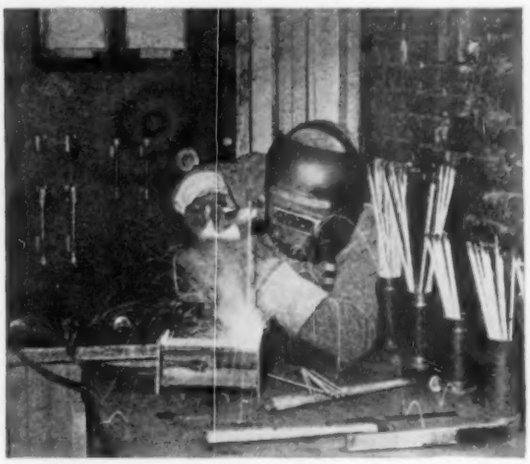
Meeting, Louisville Section



LOADING MACHINERY, used in coal mining, manufactured by the Jeffrey Manufacturing Company, is subjected to severe vibrations and stresses. Frames are all welded from specially shaped plates, bars or tubes. Murex electrodes are used, most welds being fillet welds—either single or multipass, continuous or intermittent.

RIPPERS, special heavy-duty construction implements manufactured in quantity by the Southwest Welding & Manufacturing Company for the armed forces, require approximately 325 feet of welding per unit, principally automatic. Each unit consists of three main assemblies—main frame, wheel frame and wheels. Murex Type F electrodes are specified for the welding because of their excellent physical properties, good penetration, high ductility and soundness of weld metal, which must withstand the severe daily stresses which are imposed upon this equipment.

CHEROKEE DAM GATE is one of three identical 135,000 pound giants that were 95% welded by Murex electrodes for the T.V.A. Welds were ¾" and all were peened to relieve undue stresses set up by heating, with some sections pre-heated to prevent warping. Gate members were clamped together on a large surface plate during welding operations.



PROVING GROUND for testing Murex electrodes comes to the production line of the M & T plant. Groups of electrodes are taken at random and thoroughly tested by welders for rod performance, soundness of weld metal, arc and slag action, and other characteristics. Just another reason for the superiority of Murex electrodes and their assured uniformity.

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Theodore H. Lewis, Louisville Section Chairman, presented a Certificate of Appreciation (appropriately framed for wall decoration) to Messrs. Fritsch, Vinsel, Williams and Powers, thereby ending a perfect evening and a happy landing.

MARYLAND

The January meeting, held on the 19th at the Engineers' Club, was addressed by LaMotte Grover, Welding Engineer, Air Reduction Sales Co., who spoke on "Welding in Shipbuilding."

MILWAUKEE

The January meeting was held on the 26th at the Ambassador Hotel. An after-dinner talk on "China Today" was given by Y. W. Chu, Electrical Engineer for the Chinese Government. A welding address on "Welding as Applied to Pipe Fabrication" was given by F. C. Fantz, Vice-President, Midwest Piping and Supply Co., St. Louis, Mo.

NEW JERSEY

The regular monthly meeting was held on January 16th at the Essex House, Newark. "Information Please" session, with B. Wright of the Curtiss-Wright Corp., Propeller Division, acting as chairman, was held for a half hour before the regular meeting. A film, "A.-C. Welding," was shown through the courtesy of the General Electric Co. J. H. Cooper, Chief Sales Engineer of Taylor-Winfield Corp., Warren, Ohio, spoke on the subject "Applications of Resistance Welding to Wartime Products."

The February meeting held on the 20th was also held at the Essex House. "Information Please" session, with A. Kime of the Federal Shipbuilding and Dry Dock Co. as chairman. A film, "Making Stainless Steel," was shown through the courtesy of Allegheny Ludlum Steel Corp. H. N. Ewertz, District Sales Manager for American Machine and Metals, Inc., talked on "Welding Stainless Steel."

NORTHERN NEW YORK

December 14th was "Ladies Night" for the local Section with refreshments and dancing. Four moving pictures were shown: "Birth of the B-29," "Weapons of War," "December 7th," "Behind Nazi Lines." Although it was an icy night, 62 were present.

H. R. Sennstrom of the American Locomotive Co. addressed the January 25th meeting on "Experimental Stress Analysis Applied to Welding."

NORTHWEST

The February meeting held on the 7th in the Men's Lounge, Coffman Memorial Union, U. of M., was addressed by Mario Sciaky of Sciaky Bros., Chicago, who spoke on "Electric Resistance Welding."

OKLAHOMA CITY

The regular monthly meeting was held on January 25th at the Paul Borden Capitol Hill Cafe. G. N. Sieger, S.M.S. Corp., Detroit, was the guest speaker. Mr. Sieger gave an excellent illustrated talk on resistance welding, in such a way as to make it understood by all. Mr. Sieger's talk was accompanied by slides and followed by a motion picture, entitled "Aircraft Production Processes."

The meeting was followed by a Smoker for members and guests.

PEORIA

The annual joint meeting of the Peoria Chapters of the AMERICAN WELDING SOCIETY and the American Society for Metals was held Monday, Jan. 8, 1945, in the Jefferson Room of the Jefferson Hotel. This meeting was a dinner meeting and was attended by 200 members and guests.

Technical chairman for the evening was Elmer Isgren, Plant Manager, of R. G. LeTourneau, Inc., who introduced the speaker for the evening, T. B. Jefferson, editor of *The Welding Engineer*. The subject for the evening, chosen by Mr. Jefferson, was "Welding in the Postwar Period," which he covered very thoroughly. He outlined some of the problems that will face welding in the postwar era and discussed the likely available materials of welding in the various postwar industries.

After Mr. Jefferson's speech, the meeting was opened for questions; and from the number of questions that were asked and the excellent answers that were received, the meeting was a great success.

PHILADELPHIA

A joint meeting of the local sections of the AMERICAN WELDING SOCIETY and the Society of Naval Architects and Marine Engineers was held at the Philadelphia Electric Co. Auditorium on January 15th. Leon C. Bibber, Welding Engineer for the Carnegie Illinois Steel Corp., presented an interesting address on "Ship Building."

PITTSBURGH

Nearly one hundred interested members and guests were present to hear a most entertaining discussion on "The Place of Magnetic Particle Inspection in the Welding Field" by C. E. Betz, Vice-President, Magnaflux Corp. of New York, in the Mellon Institute of Industrial Research Auditorium on January 17th.

The wide use of welding in the fabrication of highly stressed structures has made it imperative that sensitive nondestructive tests be employed to verify the integrity of critical welds. Mr. Betz described fully the magnetic particle inspection method used in this field. He also reviewed the development of this method in the welding field, describing the techniques at present in use, and indicating the trend for future applications. Various procedures for weld inspection were discussed and compared.

Following the meeting a quite lengthy discussion brought out many interesting facts on the subject. Due to illness, Chairman Chas. H. Jennings was unable to be present and the meeting was ably conducted by G. O. Hoglund, Vice-Chairman.

PUGET SOUND

The January meeting was held on January 31st at the Gowman Hotel, Seattle. A question box discussion was held preceding the dinner at which Joe Holt of Webster Brinkley Co. answered questions on the sequence for welding patches, the necessary preheat for welding alloys and the welding of aluminum to copper.

After the 7 o'clock dinner, William Snyder of the Webster Welding Co. spoke on "Helium Welding of Magnesium and Stainless Steel." Mr. Snyder was formerly with the Northrup Aircraft Co. where he was attached to their experimental department at the time they were building experimental planes of magnesium for the U. S. Army Air Forces.

Mr. Snyder traced the manufacturing of magnesium from its source down to its commercial forms of sheets, plates, bars and castings, describing the welding processes necessary to insure sound welds. He advocated welding without the addition of welding rod using a tungsten electrode with a spray of helium gas passing around the rod and over the molten metal. In order to minimize distortion, he suggested turning a slight flange on edges to be welded so that this fused metal would flow into the gap and offset the contraction caused by the heat applied.

After the completion of Mr. Snyder's speech, a technicolor and sound picture was shown on Ross Dam, the source of Seattle City Electrical Power.

ROCHESTER

The February meeting of the Rochester Section was held at Lower Strong Auditorium, University of Rochester, Feb. 1st.

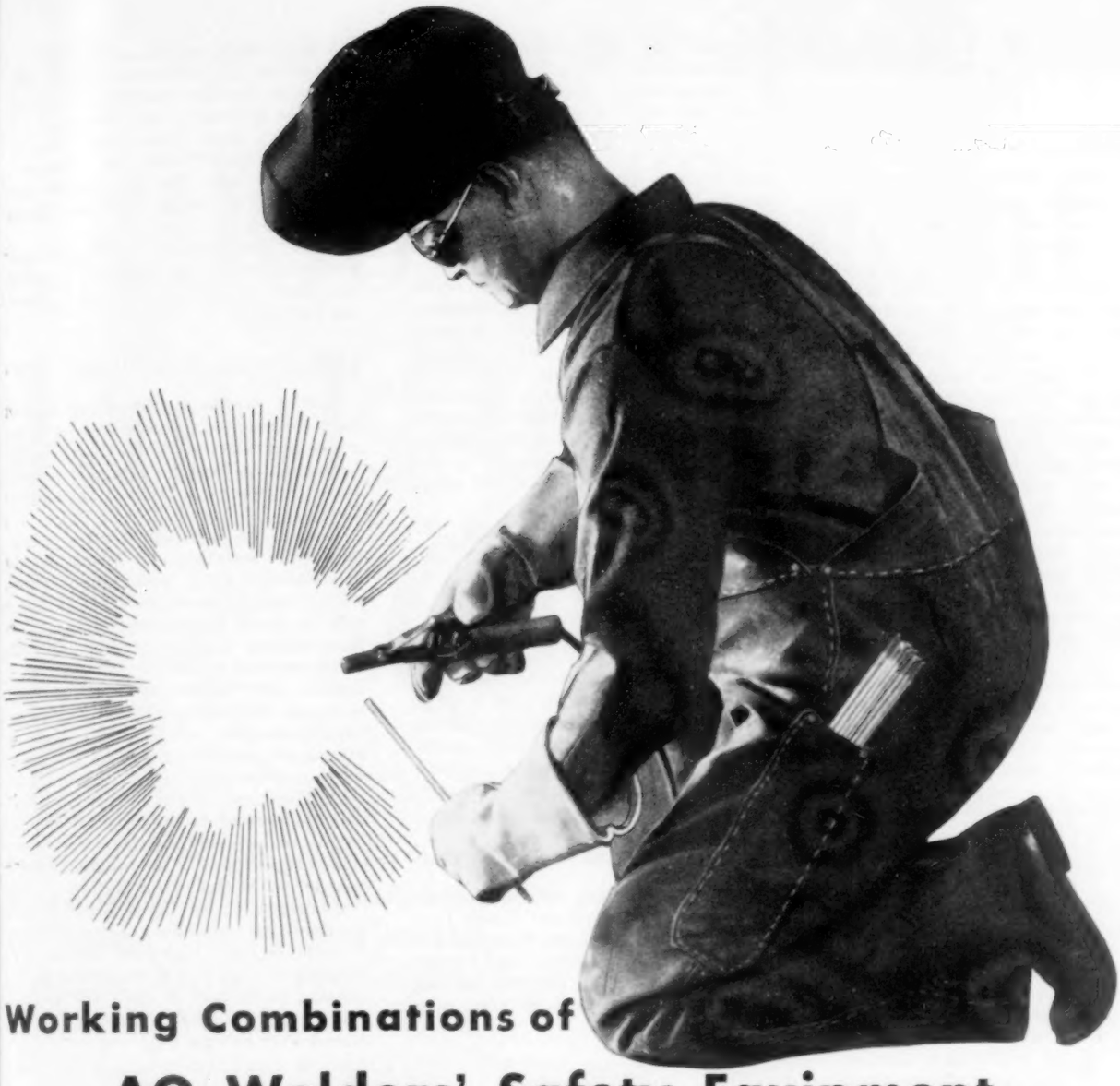
George F. Wolfe, Dravo Corp., gave a talk on "Production Line Assembly Methods as Applied to Ship Construction. His interesting lecture, supplemented by pictures, gave his audience a good idea of what it means to build ships on a production basis.

His description of how large sections of these vessels are handled and turned, so that down-hand welding may be employed, was especially significant. We realize, after listening to this talk and seeing pictures of actual construction, why it has been possible to build a world Navy and Merchant Marine in such a short space of time.

Old man Winter again visited the Eastern Section of the country with another blizzard on the day before and attendance was again small. In fact Mr. Wolfe's train was almost snowed under. He deserves a lot of credit for keeping his appointment.

The January Bowling Party was a grand success. The "eats" were exceptionally good and plentiful. The thanks of all who attended, numbering about sixty, are extended to the committee on arrangements and to the management of the hall.

The April assembly will be addressed by James F. Lincoln of the Lincoln Electric



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Co., Cleveland, Ohio. A joint meeting with the A.S.M. is being arranged for this date.

SAINT LOUIS

The St. Louis Section held its regular monthly meeting January 12th at the Engineers' Club, and the speaker of the evening was James B. Quigley of the Graver Tank & Mfg. Co. Mr. Quigley spoke on the subject of "Automatic Welding" and his treatment of the subject was essentially the same as that which was held at the Metal Congress in Cleveland last October. The discussion period that followed, however, was quite varied, and particular interest was shown in joint preparation for automatic welding, the effects of varying arc voltage and the characteristics of the welds which are normally produced automatically.

Slides were shown in illustrating his talk which covered three forms of automatic welding which Graver regularly does in their plant, and they number three—namely, shielded metallic arc, shielded and unshielded carbon arc, and submerged melt.

Attendance was in the neighborhood of 150 members and guests, and the response which we experienced at this meeting prompts us to recommend Mr. Quigley to other sections for their regular meetings, as we feel that he did an excellent job for St. Louis.

SAN FRANCISCO

The regular monthly meeting held on January 22nd at the Engineers' Club was addressed by G. A. Hughes, Senior Welding Engineer, U. S Naval Dry Docks. Mr. Hughes spoke on the subject "Important Considerations in Welding Heavy Sections." A motion picture, "Behind Nazi Guns," was shown through the courtesy of the U. S. Navy. Lieut. Commander S. V. Kemper, Jr., U.S.N.R., Material Superintendent, U. S. Naval Dry Docks, was the Technical Chairman.

SYRACUSE

O. T. Barnett, Metal & Thermit Corp., was the guest speaker at the January 11th meeting held at the Syracuse Museum of Fine Arts. Mr. Barnett spoke on "Taking Inventory of Welding Costs." Technical chairman for this meeting was A. M. D. Cassel, Smith & Caffrey.

R. T. Gillette of the General Electric Co. addressed the February 8th meeting on "Resistance Welding." Technical chairman, R. J. Greer, Carrier Corp.

WESTERN MASSACHUSETTS

The December meeting was held on the 18th. Mr. Carl W. Schaub, Engineer with the Arcos Corp., explained the metallurgical qualities of the various types of stainless steel and explained the effects on these steels when welded. Slides were shown to illustrate methods of welding stainless steel and to demonstrate applications of welded stainless steel. A very interesting question and answer period followed.

A General Electric two-reel color film was shown on A.-C. Welding.

WESTERN MICHIGAN

Mr. Harris A. Goodwin, Mid-Western District Manager of The Bastian-Blessing Co., guest speaker at the January 29th meeting, spoke on "Safety in Gas Welding and Cutting." A colored movie on "Manufacture of Carbide" was also shown. There were over a hundred present, twenty-five of whom took part in the discussion.

WESTERN NEW YORK

At a dinner meeting held on January 26th at the Forty & Eight Club. J. J. Vreeland of the Chase Brass & Copper Co. spoke on "Welding of Copper and Copper Alloys." There was an excellent turnout for an excellent speaker in very poor weather.

WICHITA

The January meeting was held in the ballroom of the Allis Hotel on Jan. 24, 1945. The Dinner Meeting began at 6:30 P.M. with 122 present for the dinner—a new record high.

The speaker for the evening was G. N. Sieger of the SMS Corp., Detroit, Mich. His subject was "Flash Welding Procedure and Applications." Mr. Sieger presented the basic fundamentals of resistance and flash welding and also went into details on the use of these processes in actual production. In addition to his talk he also presented the Walt Disney sound film entitled "Aircraft Production Processes—Welding." This film gave many good illustrations on the applications of resistance welding.

The above entertainment was also supplemented by a film on the use of goggles and safety equipment presented by American Optical Co.

YORK-CENTRAL PENNSYLVANIA

Forrest Waldo of the Air Reduction Sales Co. was the principal speaker at the mid-winter meeting of the York-Central Pennsylvania Section held on January 10th. His topic was "Innovation in Flame Cutting."

Despite the inclement weather a large number of members and friends were in attendance. They were amply repaid with a well-prepared and ably delivered talk on novel applications of the art of flame cutting in all its phases. The talk was interesting and instructive to a marked degree. Mr. Waldo answered the many questions concerning his subject in a very capable manner. Undoubtedly those in attendance profited greatly by this meeting.

G. Theisinger, of the Lukens Steel Co., who is chairman of the program committee, is to be congratulated on the continued high caliber of the program for this year in the York-Central Section.

Chairman C. E. Lewis Kerchner announced that enrollment of new members is continuing at a high rate. He also announced that plans for the annual dinner meeting to be held in April are well developed and that reservations will be accepted after February 1.

YOUNGSTOWN

A. M. Setapen of Handy & Harman addressed the December meeting in an illustrated talk on "Silver Brazing," which was well received.

District Vice-President J. F. Maine was guest. Mr. Maine will also attend the March meeting at which George Sieger of SMS Corp. will be the speaker.

1945 A. W. S. DIRECTORY

In order to conserve paper the new 1945 A. W. S. Membership Directory, now available, will be only sent to those requesting a copy. There is no charge to members of the Society. Address request to:

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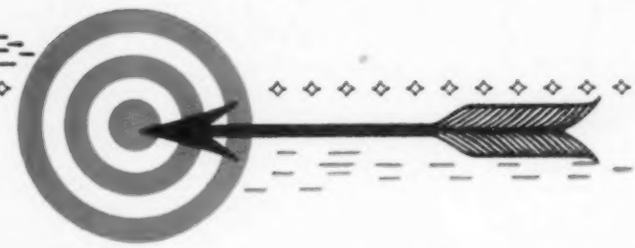

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List of New Members

January 1 to January 31, 1945

BOSTON

Lo Piano, Angelo, Joseph (C), 88 Lawrence St., Lawrence, Mass.

BRIDGEPORT

Christie, John L. (B), Handy & Harman, Bridgeport 9, Conn.
Pease, James K. (C), 51 Grove St., Shelton, Conn.

CANADA

Pullin, Alex (B), The British Corp., Register of Shipping, 84 Notre Dame W., Montreal, P. Q., Canada.
Scott, W. D. (C), c/o Can. & Gen. Finance Co., Ltd., 25 King St. W., Toronto 1, Canada.
Standing, R. O., (B), Hydro-Electric Power, The Library, Comm. of Ont., 620 University Ave., Toronto 2, Canada.
Waite, Matthew J. (B), 201 Willingdon Ave., Kingeton, Ont., Canada.

CHATTANOOGA

Green, George G. (C), 1329 Chestnut St., Chattanooga 2, Tenn.
Stuff, Paul H. (B), c/o Ross-Meehan Foundries, 1601 Carter St., Chattanooga 1, Tenn.

CHICAGO

Barton, Cecil M. (B), McKinney Steel & Sales Co., 8 Madison St., Waukegan, Ill.
Dempsey, Edw. J. (C), Electro-Motive Div., of General Motors Corp., La Grange, Ill.
Evans, M. C. (A), International Harvester Co., 180 N. Michigan Ave., Chicago, Ill.
Keleher, Wm. H. (B), Merchants Despatch Trans. Corp. & Northern Refrigerator Line, Inc., 600 S. Michigan Ave., Chicago 5, Ill.
Kroupa, John F. (C), 2525 Home Ave., Berwyn, Ill.
Lilleqvist, G. A. (B), American Steel Foundries, Research Laboratory, East Chicago, Ind.
Rexroth, E. A. (C), 1617 S. 59th Ave., Cicero 50, Ill.
Silver, I. R. (B), Chicago Welding Sales Co., 3349 Ogden Ave., Chicago, Ill.
Spudic, John, Pvt. (B), A.P.O. 72, c/o P.M., San Francisco, Calif.
Stern, Jack (C), 2114½ N. Kedzie Ave., Chicago, Ill.
Vitha, George J. (C), 1524 East Ave., Berwyn, Ill.
Wengler, James E. (B), 16 E. 120 St., Chicago, Ill.

CINCINNATI

Ebel, Ronald A. (C), J. J. Dupps Co., 408 American Bldg., Cincinnati 2, Ohio.
Hafer, Ralph (C), 2128 Winton St., Middletown, Ohio.
Hines, Albert E. (B), R. R. 1, Cozaddale, Ohio.
Kelley, G. H. (C), c/o J. J. Dupps Co., Echardt Rd., Germantown, Ohio.
Moorhead, Russel (C), 1065 Azel Ave., Hamilton, Ohio.
Murray, Howard E. (B), Columbia Mach. & Engineering Co., Hamilton, Ohio.
Smith, G. W. (B), G. W. Smith & Sons, 116 S. Sperling Ave., Dayton 3, Ohio.

CLEVELAND

Currens, C. C. (B), Fidelity & Casualty Co., 1230 B. F. Keith Bldg., Cleveland 15, Ohio.
Irrgang, William (B), 1696 Sheridan Rd., South Euclid, Ohio.
MacCleery, Albert M. (C), American Bureau of Shipping, 660 Rockefeller Bldg., Cleveland, Ohio.
Marty, A. H., Jr. (B), A. H. Marty Co., 6900 Union Ave., Cleveland 5, Ohio.
Mooney, John L. (B), The Mooney Iron Wks. Co., 3319 E. 80th St., Cleveland, Ohio.
Pertz, Louis, Jr. (C), 4400 Ingleside Rd., Warrensville Hts., Ohio.
Petley, Henry (C), Firestone Tire & Rubber Co., 977 Whittier Ave., Akron, Ohio.
Rooker, Earle J. (B), Square D Co., 721 Hanna Bldg., Cleveland 15, Ohio.
White, Herbert E. (C), 3133 Fairfax Rd., Cleveland Hts. 18, Ohio.
Wortman, William G. (C), R. D. 2, Willoughby, Ohio.
York, Albert B. (B), 2679 E. 100 St., Cleveland 4, Ohio.

COLUMBUS

Black, Norman C. (B), R. R. 5, Lima, Ohio.

DETROIT

Arakelian, William Russell (C), 19630 Conley Ave., Detroit 12, Mich.
Brantner, Jack (C), 8275 Whitcomb, Detroit 27, Mich.
Demski, George S. (C), c/o Tube Fabricators, Inc., Pinconning, Mich.
Duer, Paul L. (C), 453 West Liberty, Hubbard, Ohio.
Farris, Jack L. (C), Saginaw Welding Supply Co., 816 E. Genesee St., Saginaw, Mich.
Gable, Joseph A. (C), 13537 Kentucky, Detroit 4, Mich.
Heiden, Ray W., Jr. (C), 13351 Wilfred, Detroit, Mich.
Kaso, Nick A. (C), 69 Woodward Hts. Blvd., Ferndale 20, Mich.
Kitterman, Paul (C), 1935 Dorothea, Berkley, Mich.
Lindeman, William H. (C), 5918 Haverhill, Detroit 24, Mich.
MacKinnon, James S. (C), 3310 Lothrop, Detroit 6, Mich.
Muir, Emery R. (C), 24551 Telegraph Rd., Flat Rock, Mich.
Patterson, Chas. F. (C), 8032 Kentucky, Detroit 4, Mich.
Rose, Harry S. (B), Progressive Welder Co., 3050 E. Outer Drive, Detroit 12, Mich.
Swanson, Kenneth P. (B), Progressive Welder Co., 3050 E. Outer Drive, Detroit, Mich.
Von Deventer, R. E. (B), Packard Motor Car Co., 1580 E. Grand Blvd., Detroit 32, Mich.

HARTFORD

Danipman, Robert J. (B), 195 Collins St., Hartford, Conn.
Detweiler, Thos. H. (B), 310 Main St., Rocky Hill, Conn.
Henderson, Wayne G. (B), The Travelers Insurance Co., Hartford, Conn.
McLaren, John (B), The Travelers Insurance Co., Main St., Hartford, Conn.
Mortimer, John W. (B), 82 Plymouth Lane, Manchester, Conn.
Taylor, Shaw (B), The Whitlock Manufacturing Co., Hartford, Conn.
Smith, S. Arnold (B), 1377 Main St., Newington 11, Conn.

INDIANA

Mullendore, William O. (C), 1809 W. 9th St., Anderson, Ind.
Sweeny, W. O. (B), Haynes Stellite Co., Kokomo, Ind.

KANSAS CITY

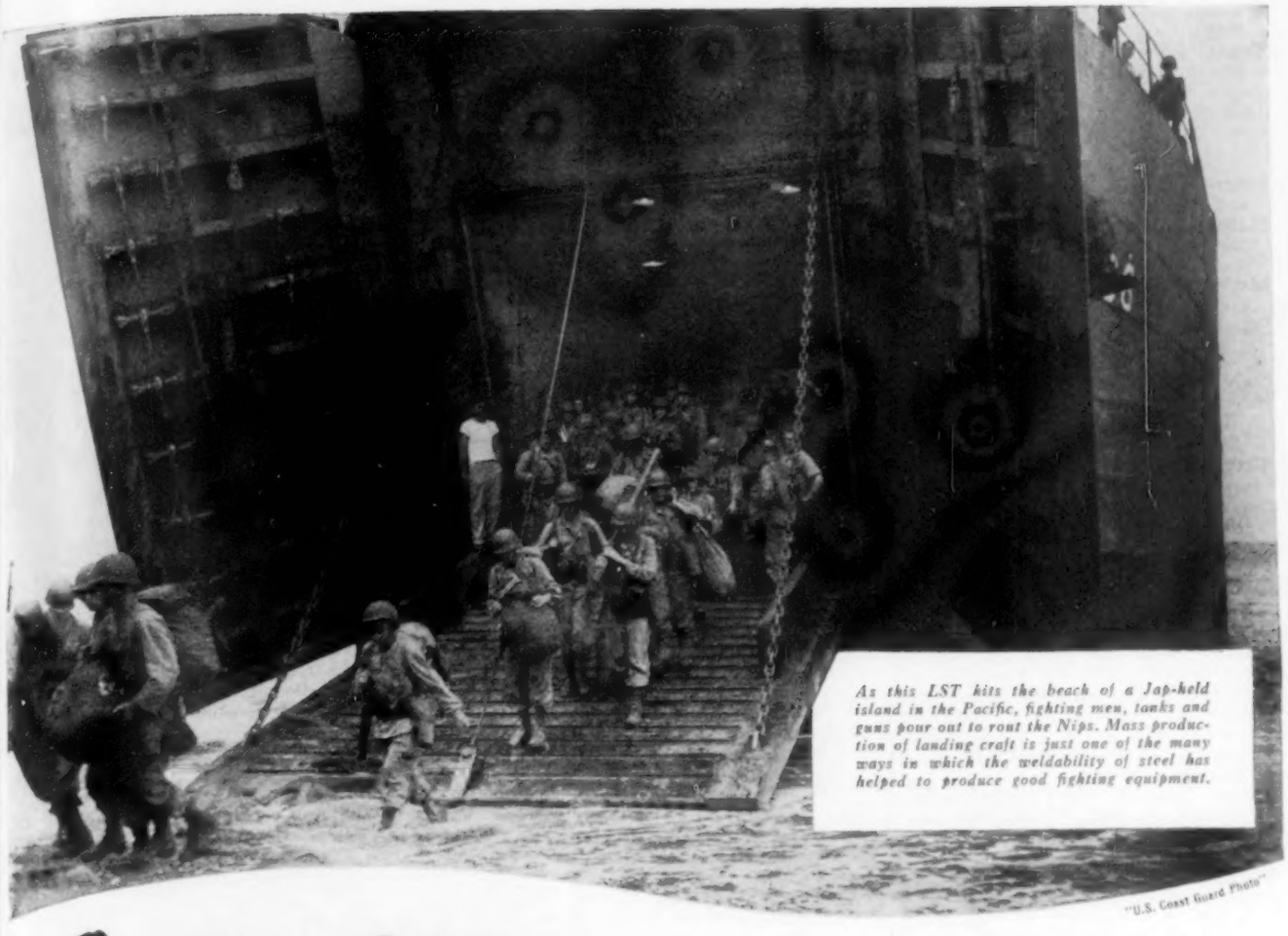
Carberry, John L. (B), 4916 Wabash, Kansas City, Mo.
Gould, Harold M. (B), 502 North Liberty St., Independence, Mo.
Hays, Dan F. (C), North American Aviation, Kansas City, Kan.

LEHIGH VALLEY

Gordon, Paul J. (C), 765 Washington Ave., Bethlehem, Pa.

LOS ANGELES

Binder, R. W. (C), Bethlehem Steel Co., Box 58, Watts Sta., Los Angeles 2, Calif.
Gorich, George M. (C), 3231 Maine St., Long Beach 6, Calif.
Green, Russell L. (C), c/o G. Wilson, Bridge & Bldg. Supr., Union Pacific R.R. Co., 2025 Hunter St., Los Angeles, Calif.
Grier, Richard E. (C), 2494 Beachwood Dr., Hollywood 28, Calif.
James, Davis L. (B), 1053 W. 121st St., Los Angeles, Calif.
Lawson, E. L. (C), National Cylinder Gas Co., 4950 Santa Fe Ave., Los Angeles 11, Calif.
McKelvey, Henry K. (C), 5237 Greenmeadow Rd., Long Beach 8, Calif.
Pendrell, C. C. (B), Haynes Stellite Co., 2305 E. 52 St., Los Angeles 11, Calif.
Schiebel, Roy O., Jr. (C), Magnaflux Corp., 1566 E. Slauson Ave., Los Angeles 11, Calif.



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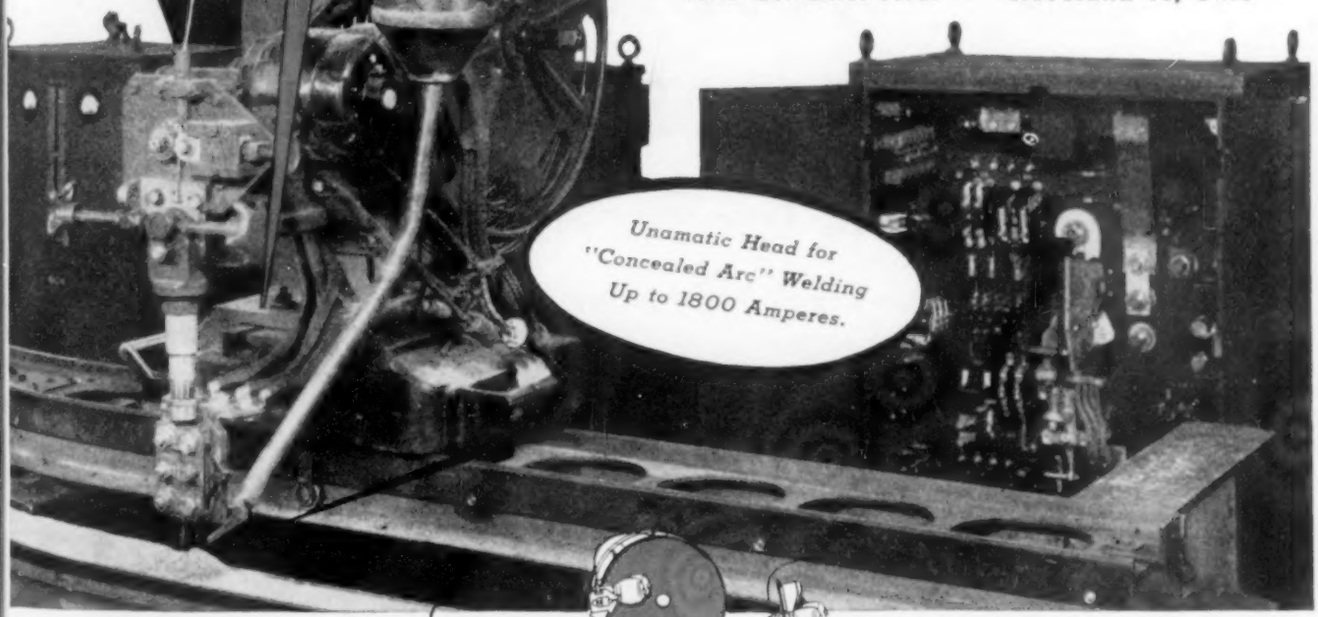

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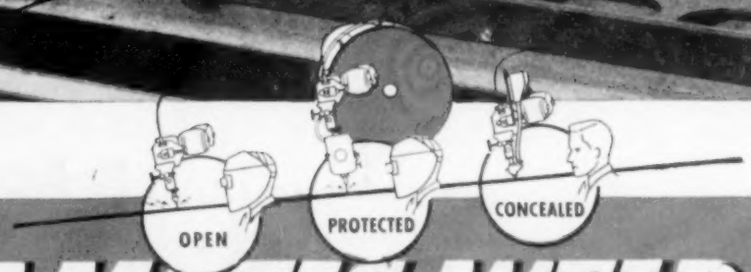

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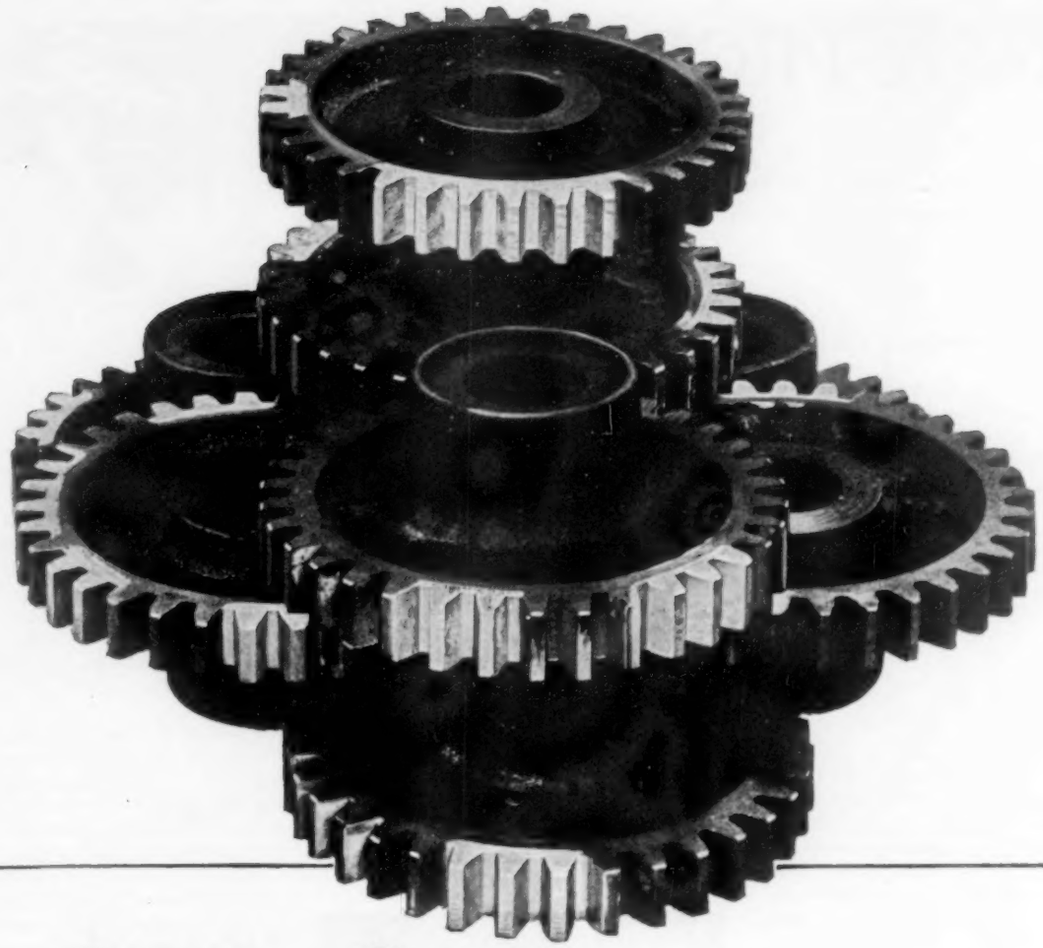

Spare Gears... Tobin Bronze Welded

eliminate down-time on war jobs

READY TO GO to work again, this group of worn and broken gears from wire braiding machines at the Metal Hose Branch of The American Brass Company, were quickly and economically reconditioned with Tobin Bronze* Welding Rod.

Through the use of these spare gears, the machines were kept in operation 24 hours a day on vital war work, braiding wire over flexible metal tubing for ships, tanks, aircraft and landing craft.

"Don't Scrap It... Bronze Weld It!" is more than a slogan—it's a NECESSITY in many plants. Publication B-13 describes Anaconda Welding Rods, suggests uses and procedures. Write for a copy. 45109

*Reg. U. S. Pat. Off.

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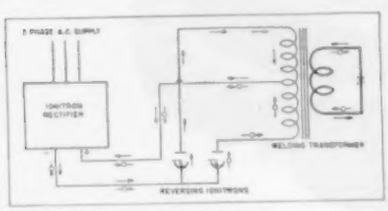
Anaconda Bronze Welding Rods

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

THREE-PHASE RESISTANCE WELDER

A new principle for the spot welding of steel in heavy gages with a balanced three-phase load has been announced by Sciaky Bros., 4915 West 67th St., Chicago, Ill.

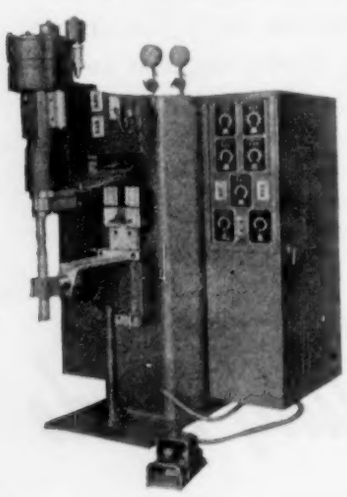


As shown in the diagram, all three phases of the a.-c. line current are rectified to d.-c. and supplied to the welding transformer through a system of reversing ignitron tubes. These tubes allow the current to pass through the center tapped primary first in one direction, and then in the other. Thus, the induced welding current in the secondary is a continuous alternating impulse of low frequency—of ideal wave shape and magnitude.

This system helps overcome limitations encountered, where single-phase a.-c. welders are subject to heavy loads. These are: disturbance to the usual three-phase supply in the unbalanced load, the heavy reactive load, which results in low power factor, and the high power demand. Power installation and operating costs are reduced by providing (1) a balanced three-phase load, (2) operation at near unity power factor and (3) decreased power demand.

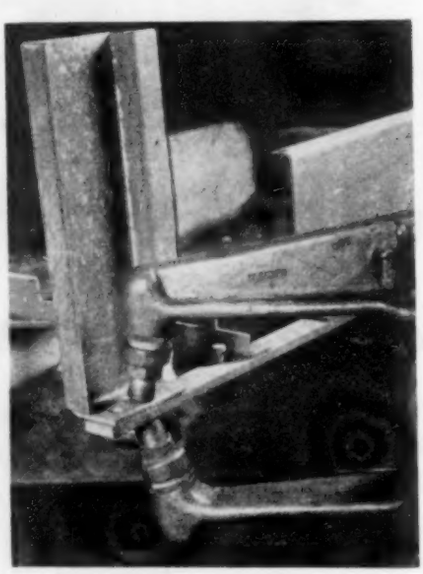
A typical spot welder employing the "Three-Phase" principle (type PMCO.2T-4) is rated 100 kva. at 50% duty cycle and operates at 85% power factor. A preheating current and variable pressure are provided. Capacity on mild, scaly or stainless steel is from 0.032 in. plus 0.032 in. up to and including 0.312 in. plus 0.312 in. Speed on two thicknesses of 0.062 in. is 90 spots per minute.

The principle has been effectively applied to seam welders for aluminum, heavy-duty projection and flash welders.



GUN WELDER BRAZES COPPER

Engineers at the East Pittsburgh Plant of Westinghouse have adopted a "gun welder" for spot brazing large copper sections. Difficulty is frequently encountered in fabricating work of this kind because the shape and size of the sections hinder



their passage through a press type welder. Here, instead of the work being brought to the welder, the welder is brought to the work. Since copper is a low resistance metal, molybdenum tips are used to supply the necessary heat—by conduction—to the parts being brazed. Recirculated water is used as a refrigerant.

SILVER BRAZING (SOLDERING) OF CAST IRON

Commercial silver soldering or brazing of cast iron has heretofore been considered impractical. The scale, graphite and sand

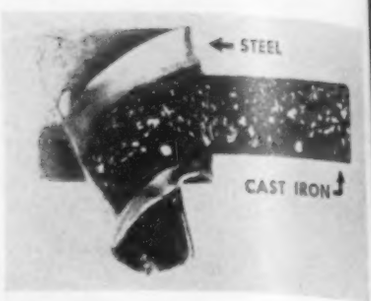


Fig. 1

inclusions on the casting surface prevented a firm, uniform bond.

The use of solder containing silver, whose melting point is 1000° F. or greater is termed "silver brazing."

The tensile strength of silver brazing alloys such as A.M.S. 4770, being 40,000 psi. or greater, if a firm and uniform brazed bond exists between cast iron and steel, the lower tensile strength material, viz., cast iron should break before the bond.

Figure 1 illustrates a breach of such a joint between silver-brazed cast iron and steel.

The cast iron has been ruptured showing the strength of bond between the A.M.S. 4770, the cast iron and the steel.

To obtain the uniform strong bond shown in Fig. 1, it is not only necessary to remove all dirt, grease, oil and oxides from the surface but it is also necessary to remove those ingredients of the iron (necessary from a physical standpoint but undesirable from a bonding standpoint such as graphite, combined carbon and sand inclusions).

A combined cleaning and surface preparation process has now been developed by Kolene and is in commercial use for preparing cast-iron surfaces, either machined or unmachined, for this silver-brazing operation.

Figure 2, a photomicrograph of 750 diameters, shows the penetration of A.M.S. 4770, into the apertures from which the graphitic carbon or sand inclusions have been removed and the strong uniform bond between the steel, grey iron and silver-brazing material.

This Kolene process of surface preparation is carried out by suspending parts in an open container of catalyzed molten salts through which an electrical current is passed. The surface impurities are re-

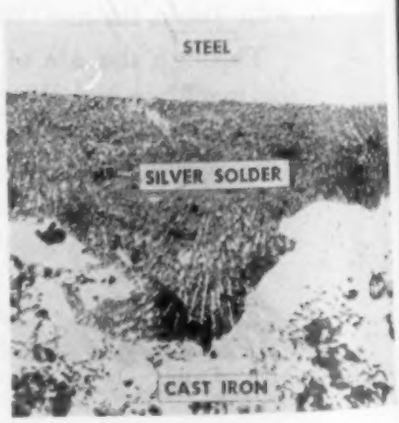
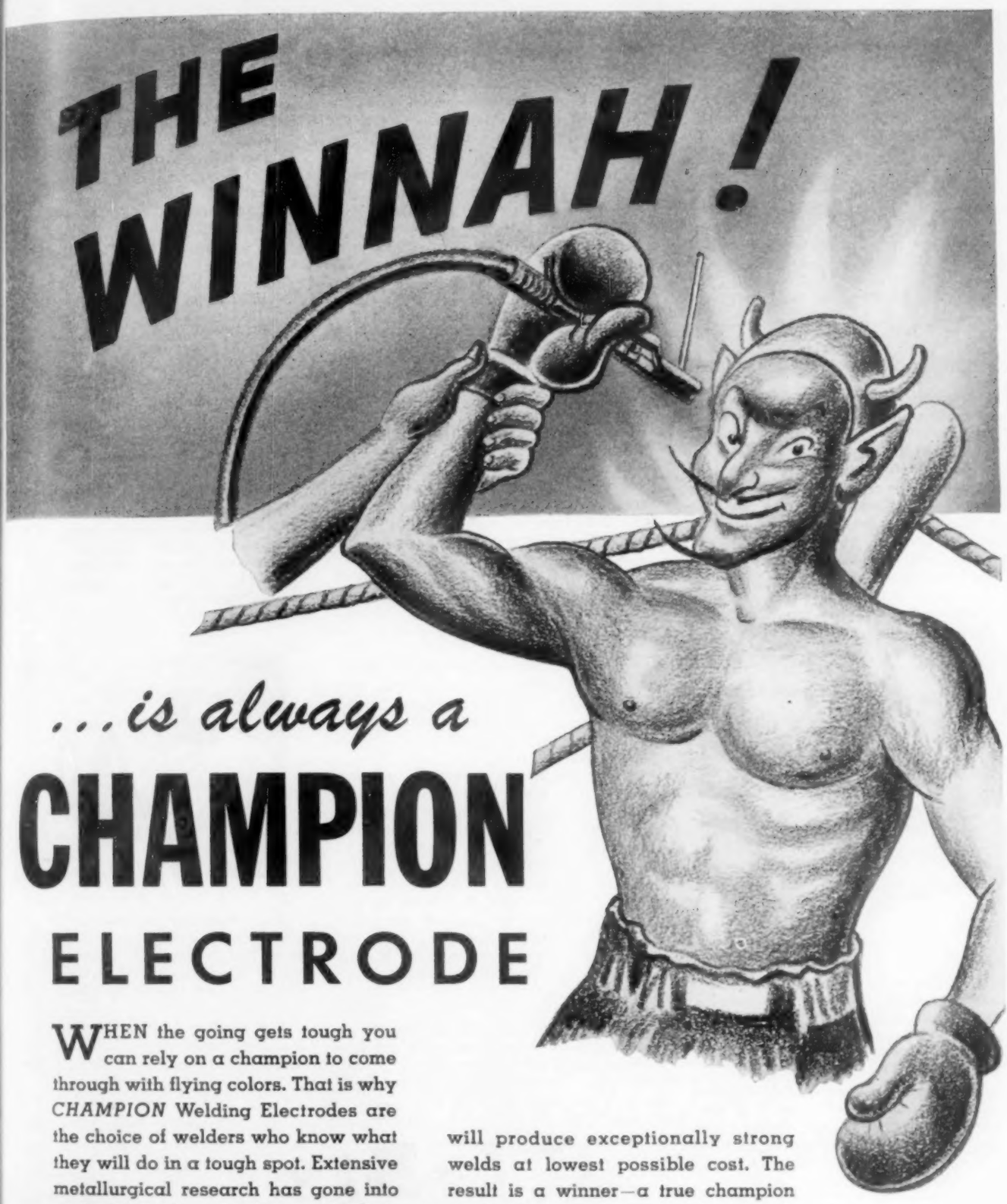


Fig. 2

THE WINNAH!



. . . is always a

CHAMPION ELECTRODE

WHEN the going gets tough you can rely on a champion to come through with flying colors. That is why *CHAMPION* Welding Electrodes are the choice of welders who know what they will do in a tough spot. Extensive metallurgical research has gone into perfecting a line of electrodes which will produce exceptionally strong welds at lowest possible cost. The result is a winner—a true champion both in name and performance.

WELDING CHAMPION ELECTRODES

THE CHAMPION RIVET CO.

11400 HARVARD AVE. • CLEVELAND, OHIO

EAST CHICAGO, IND.

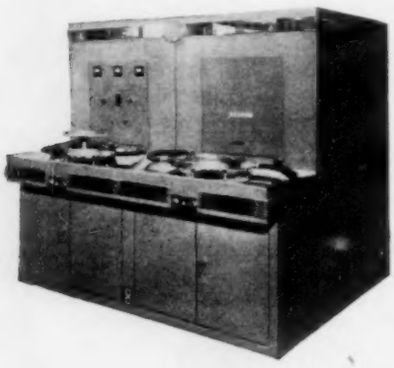
moved by the formation of oxidation and reduction members in this Kolene bath, as desired. The surface to be silver brazed is then fluxed such as with A.M.S. 3410 and silver (soldered) brazed, as with A.M.S. 4770, in a conventional manner.

It has been found possible with this process to join steel stampings, tubing, pipe, etc., to cast iron fittings and parts.

The discovery of this Kolene procedure of surface preparation will permit designing engineers greater latitude in the use of grey iron castings which must subsequently be joined to other ferrous or some nonferrous metals. Kolene Corp., 315 Boulevard Building, Detroit 2, Michigan.

NEW 50-KW. ELECTRONIC HEATER

A new 50-kw. electronic heater for surface and localized hardening of gears, rods and other parts and for annealing, brazing and soldering operations, has been announced by the Industrial Heating Division of the General Electric Co. Ideal for use in metal-working plants, the new heater incorporates all of the important features of the 5- and 15-kw. G-E heaters and, in addition, is capable of heat treating much larger parts or the same size parts in less time. This heater is readily applicable for many different heating jobs merely by changing the induction-coil fixture.



Available in models rated either 230 or 460 v., 3 phase, 60 cycles, this heater is unusually easy to operate. The parts to be heated are positioned in the fixture, and the START button is pressed. Automatic controls then regulate the heating and quenching cycles, assuring duplication of results on each part. An attached work table provides two heating positions, permitting full utilization of the high-frequency power supply to secure maximum production.

"BREN-DEL" VALVE

We are all familiar with the hazard of a broken oxygen line in the close proximity of oil, oily waste or clothing, and other combustibles, also the speed at which a severed oxygen hose burns. When "Bren-Del" valves are used this hazard is practically eliminated, since the valve immediately closes automatically.

Many serious accidents have occurred in compartments of ships, etc., through gas lines being accidentally severed and quickly filling the space with a dangerous mixture of air and gas, which exploded causing loss of life and heavy damage. When "Bren-Del" valves are used the hazard is greatly reduced, since the valve closes automatically and only a small amount of gas is permitted to escape. (Approx. 10 cu. ft. per hr.)

Another safety feature of the acetylene or fuel gas valve is the flash-back check which is built into the "Bren-Del" valve. While not intended to take the place of hydraulic back pressure valves, in large piping systems, this feature does prevent flashbacks in the hose from getting into the main lines or damaging the regulators.

Further information may be obtained from R. W. Brendle and Co., P. O. Box 2347, Tampa 1, Fla.

ALL-PURPOSE BRAZING FURNACE

Wartime applications of brazing and powder metallurgy forecast many shortcuts in fabricating peacetime products . . . shortcuts that will make a big difference in meeting postwar competition.

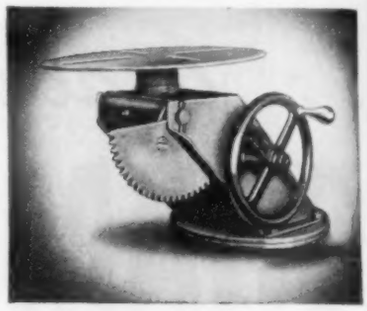
A new, all-purpose furnace to meet the need for the most modern and efficient production equipment has been developed by Lindberg Engineering Co., Chicago. It is designed for silver brazing at low temperatures, copper brazing at high temperatures, powder metallurgy, bright annealing, general tool hardening and high-speed tool hardening. Unusual flexibility of use results from its wide range of attainable working temperatures—from 1300 to 2500° F.

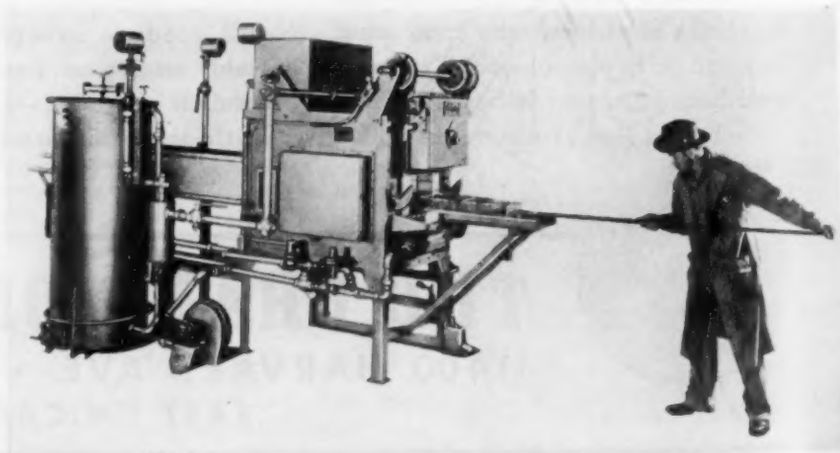
The construction of this new furnace permits the handling of heavy loads at high temperatures, making its use especially efficient for the sintering of powdered metals where each piece may weigh as much as several hundred pounds. Also, handling work in and out of the furnace has been made easier by the use of efficiently designed loading and unloading platforms. Furnace shutdowns are forestalled by the use of Globar type heating elements that are quickly and easily replaceable.

Hydryzing atmosphere, precombusted gas and dry hydrogen atmosphere may be used for prevention of oxidation and discoloration, insuring work that is bright and clean. The furnace is protected from infiltration of outside air by the use of a flame curtain at both the charge and discharge doors of the furnace. The curtain ignites automatically when the doors are opened. This is a further protection against oxidation. A gas-tight, water-cooled cooling chamber is filled with the proper atmosphere to prevent oxidation and discoloration during cooling. Full information is available in a new bulletin, No. 200, which you can get by writing Lindberg Engineering Co., 2444 West Hubbard St., Chicago 12, Ill.

BENCH MODEL 1H POSITIONER

Sturdy and compact, this hand-operated positioner provides a handy tool to facilitate production and repair welding, assembly, overhauling, grinding, drilling, hard-surfacing and similar operations on all small work. Its ability to handle small units efficiently makes the Model 1H a versatile machine for welding, assembly, maintenance and repair shops. The capacity of this Ransome Bench Model Positioner is 100 lbs. with the center of gravity three inches above table. It has a tilting range of 150°, revolves 360°, and can be locked in position at any degree of tilt. The 16-in. table top is equipped with $^{9}/_{16}$-in. slots. Swivel base is available if desired.



The Ransome Machinery Co. now manufactures welding and work positioners from 100 lb. capacity hand-operated to 40,000 lb. motor-operated, also turning rolls and other special positioning equipment.

For further information address the Ransome Machinery Co., Subsidiary of Worthington Pump and Machinery Corp., 1473 S. Second St., Dunellen, N. J.